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A COMPARISON OF VELOCITY PROFILES OBTAINED FROM
FEB 81 T B SANFORD, J H DUNLAP, R G DREVER

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APPLIED PHYSICS LABORATORY

A DIVISION OF THE WASHINGTON STATE UNIVERSITY

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**A COMPARISON OF VELOCITY PROFILES OBTAINED FROM
AN EXPENDABLE TEMPERATURE AND VELOCITY PROFILER (XTVP)
AND AN ACOUSTICALLY TRACKED PROFILER AT THE ATLANTIC
UNDERWATER TEST AND EVALUATION CENTER (AUTEC),**

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ABSTRACT

A series of nearly simultaneous drops of two velocity profilers was made at the Atlantic Underwater Test and Evaluation Center (AUTEC). One profiling method was based on the measurement of motionally induced electric currents by an expendable device. This profiler, the Expendable Temperature and Velocity Profiler (XTVP), was compared with an acoustically tracked free-fall device operated by personnel of the Johns Hopkins University's Applied Physics Laboratory. Based on drops separated by less than 100 m horizontally and about 50 minutes in time, the two sets of profiles were found to agree within about 1 cm/s rms for east and north horizontal velocity components.

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I. INTRODUCTION

In early May 1979, an experiment was conducted at AUTECH for the purpose of establishing the performance of the XTVP (Expendable Temperature and Velocity Profiler). Numerous XTVP profiles were obtained, separated in time and space by 10 minutes and 100 m from those obtained with an acoustically tracked free-fall profiler operated by personnel of the Applied Physics Laboratory, Johns Hopkins University. The primary purpose of the experiment was to validate the measurements of the XTVP probes against the APL/JHU acoustically tracked velocity profiler's measurements at depths greater than 200 m. In addition, the performance of the XTVP's in the upper 200 m was examined under various launch conditions, including distance from boat at launch. Tests were also performed with specially produced probes having shorted electrodes or preamplifiers and special weight shapes. Pressure measurements were made with some probes to determine the depth versus run-time relation. The performance of the XTVP was also evaluated by comparing simultaneous or nearly simultaneous XTVP profiles.

II. INSTRUMENTATION

APL/JHU Current Profiler

For this experiment, the APL/JHU velocity profiler was tracked by the AUTECH acoustic range. From the time series of profiler position, the vertical velocity profile was determined. Implicit in this method is the assumption that the horizontal length scales are long compared to 100 m. This allows velocity measurements at various horizontal positions to be presented as a vertical profile taken at one position.

The profiler, described in APL/JHU document STD-R-138, Chapter IV, System Description, is shown in Figure 1. It consists of a pressure vessel enclosing a clock, electronics, and an AUTECH-supplied acoustic pinger assembly. Either synchronous or asynchronous tracking for the range is acceptable, but it is important that tracking uncertainties be as low as possible (<30 cm on a point-to-point basis). The profiler, which weighs 225 pounds in air, is dropped into the ocean without a tether, and descends at approximately 30 cm/s. Upon reaching a preset depth, a pressure-actuated mechanism releases a lead weight, and the unit returns to the surface at the same rate of 30 cm/s. Current profile data are gathered on both the descent and the ascent. Additional descriptions of the profiler can be found in Wenstrand (1979).

The XTVP Current Profiler

The XTVP velocity profiler [Drever and Sanford (1980) and Fig. 2a] is a ship-launched expendable instrument whose development is based on a larger, nonexpendable instrument also developed by Sanford, Drever, and Dunlap (1978). The probe takes a vertical profile of the relative horizontal velocity vector by measuring the voltages induced by the motion of the sea and the instrument through the geomagnetic field. The term "relative" is used in the sense that the measured velocity is offset by an unknown constant velocity.

The XTVP consists of a probe similar to that of a Sippican XBT, but stretched an additional 12 inches. A block diagram of the electronics is given in Figure 2b. The thermistor used is identical to that in a standard Sippican XBT. A depth sensor is not part of the present design, but depth sensors were installed on several probes used in the tests reported here.

Three signals, electric field, compass direction, and temperature, are sent via FM transmission to an on-boat receiver over a two-wire, balanced line. The received signal is sent to an analog recorder and to the FM receiver/demodulator for recording and plotting.

Seventy-nine probes were manufactured for this experiment. Of these, only 45 were standard units of either the model 4's built by Woods Hole Oceanographic Institution or the Sippican-made model 5's. The special units were built to investigate noise sources and vehicle fall characteristics. For example, 16 units of each model transmitted pressure measurements in place of temperature. The pressure measurements provide a refined relation of fall rate versus elapsed time. The complete complement is presented in Table 1.

Table 1. Description of the XTVP's by Type, Model, and Number

<u>Type</u>	<u>Model 4</u>	<u>Model 5</u>
Standard units	9	36
Pressure measuring	6	6
Pressure measuring and		
10° afterbody fins	2	2
15° afterbody fins	2	2
20° afterbody fins	2	2
Blunt nose weight	4	4
Shorted electric field amplifier	3	3
	<hr/> 24	<hr/> 55

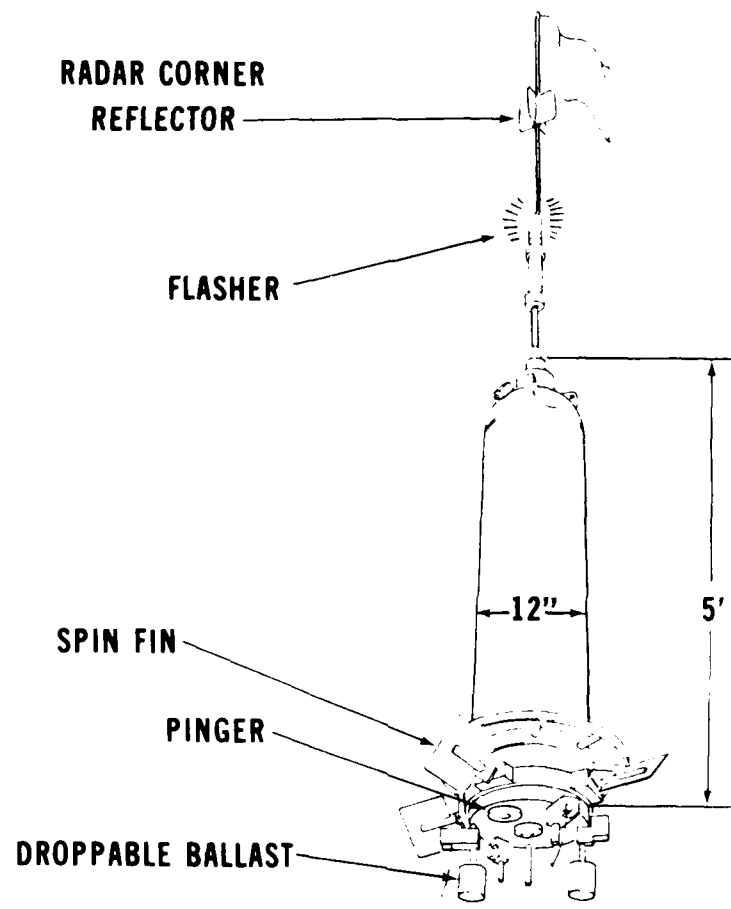


Figure 1. The APL/JHU Acoustically Tracked Profiler

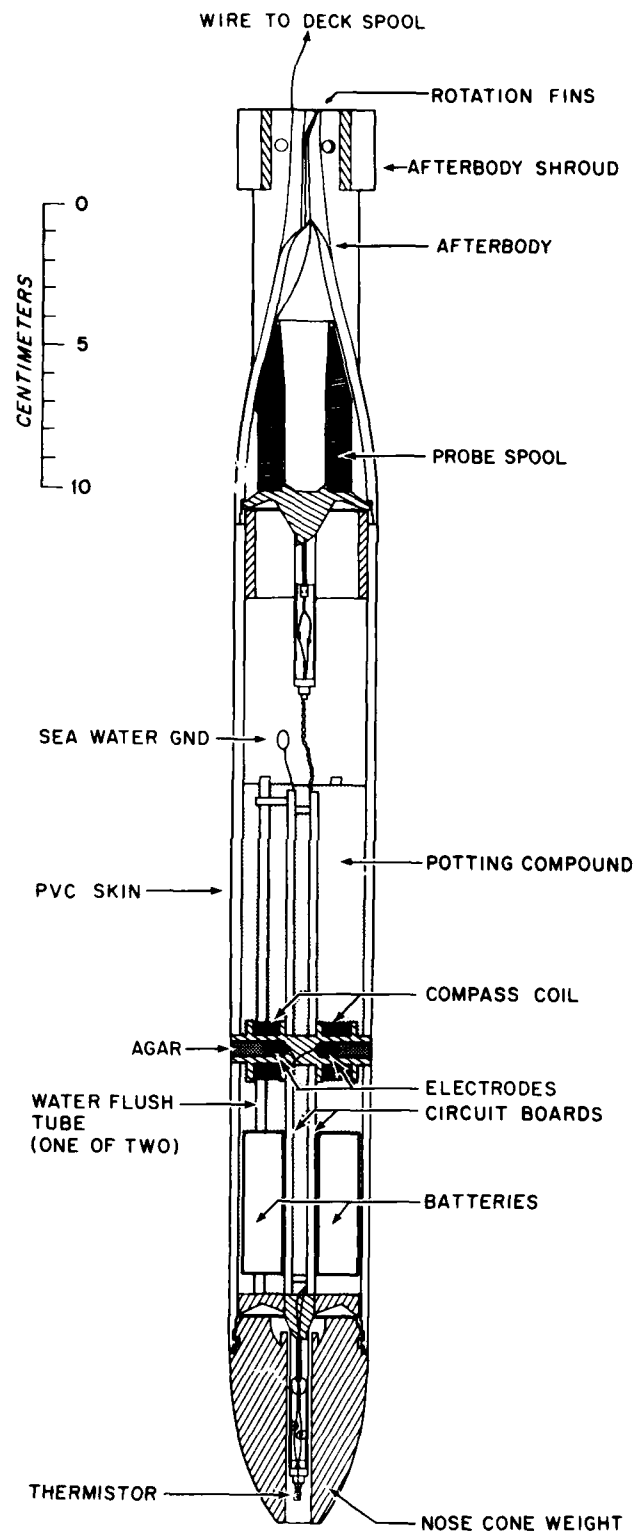


Figure 2a. Expendable Temperature and Velocity Profiler (XTVP-5)

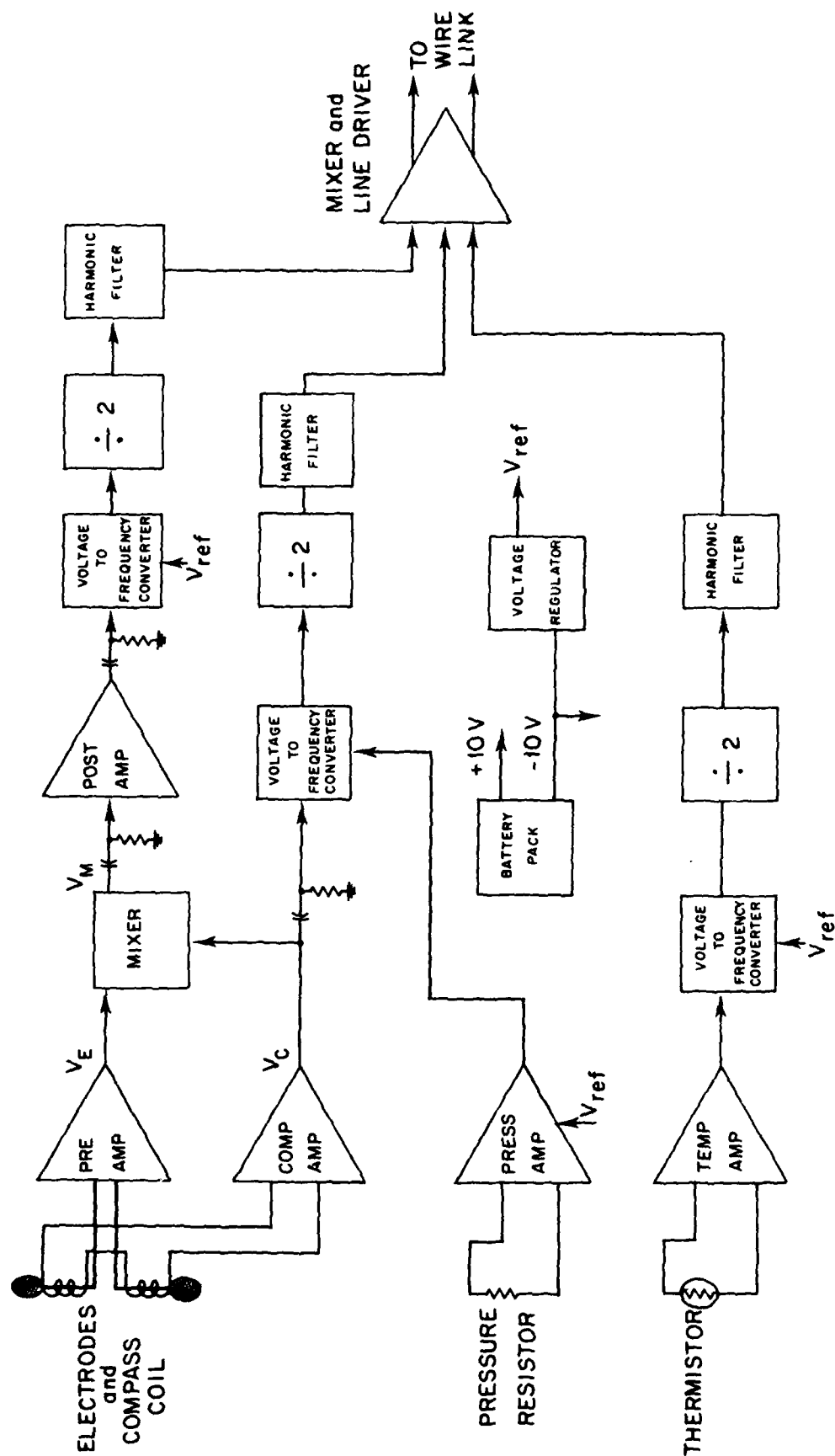


Figure 2b. XTVP Block Diagram

III. OPERATIONS

The XTVP probes and supporting instrumentation were installed aboard the R/V Cape, a vessel owned and operated by the Applied Physics Laboratory, Johns Hopkins University. Two standard Sippican XBT launchers were used. One was the stanchion-mounted, breech-loaded launcher and the other was the hand-held, plastic launcher with about 100 feet of electrical cable. The electronics were installed in the laboratory beneath the main deck just forward of the steering room. The laboratory was linked to the bridge and control personnel via internal voice units and to shore with a UHF radio. All drops except those from the towed rubber boat were made from the vessel's side.

The operational procedure was to have the Cape directed to a predetermined site for the launch of an APL/JHU tracked profiler. Once this profiler was deployed and falling, the deployment scheme for XTVP probes was to have the Cape execute loops at slow speed (5 knots) following navigational instructions from the range control center. As the Cape neared the closest point of approach to the falling profiler, an XTVP probe would be released. The goal was to release the probe within 100 m horizontally of the APL/JHU profiler. This goal was achieved in 32 out of 45 intercomparison drops. In no case was the separation greater than 200 m.

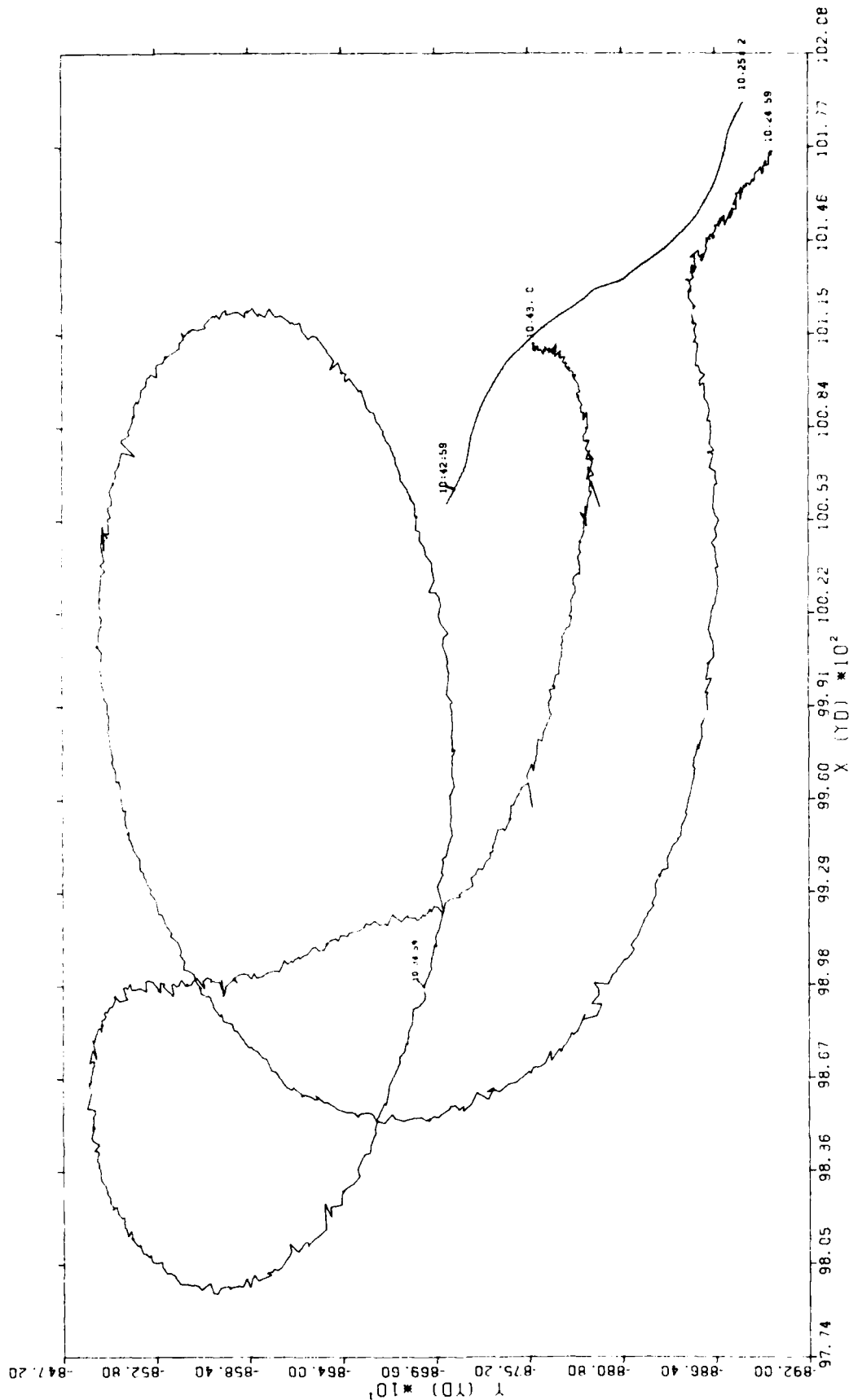
The positions of the Cape and the acoustically tracked profilers are shown in Figures 3a through 3m (provided by Dr. David Wenstrand of APL/JHU). Note that the X and Y scales are in yards and are not equal. The track of the Cape can usually be distinguished from that of the profiler by its larger extent and more loop-like character. The horizontal separation between the ship and the tracked profiler at the time of XTVP deployment cannot be easily determined from these figures and is listed in Table 2.

A log of the joint observations is presented in Table 2. The depth and range of the APL/JHU profiler are given, based on the computer printouts provided by Dr. Wenstrand. The CTD position information was provided by Mr. Stephen A. Mack. Cryptic, but useful, comments are provided about the type of observation, the maximum depth or data quality, etc.

Position data have been abstracted from the vessel and profiler tracking printout and are presented in Table 3. The vertical and horizontal separation information provided in Table 2 was determined from these data. No correction has been made for the 15-yard separation between the radar transponder or in-water acoustic source used to track the vessel and the launch position of the XTVP probes, except for when the probes were launched from a rubber boat towed behind the vessel. In the latter case, the vessel/launch position difference is about 50 yards. Since the vessel was receding from the profiler for each XTVP deployment, this 50 yards has been subtracted from the vessel/profiler separation or range.

DROP 3 CAPE 136 MAY 79

DROP 3 SHEAR PROFILER T40 MAY 79



30.0 SECONDS BETWEEN MARKERS

Figure 3a. East (X) and North (Y) trajectories of the R/V Cape and the APL/JHU profiler for Drop #3

0400 4 0400 100 0400 100

0400 4 0400 100 0400 100

923.00 908.00 894.00 880.00 866.00 852.00 837.00 823.00 809.00
100.00 100.00 100.00 100.00 100.00 100.00 100.00 100.00 100.00

Figure 5b. East (X) and North (Y) trajectories of the R/V Cape and the APL JHU profiler for Drop #4.

CAGE 5 CHOP 100 MB 10

CAGE 5 STEADY PROFILES MAY 79



Figure 3c. East (X) and North (Y) trajectories of the R/V Cape and the APL/JHU profiler for Drop #5.

CHOP 6 SINEUR PROFILER 140 MAY 79

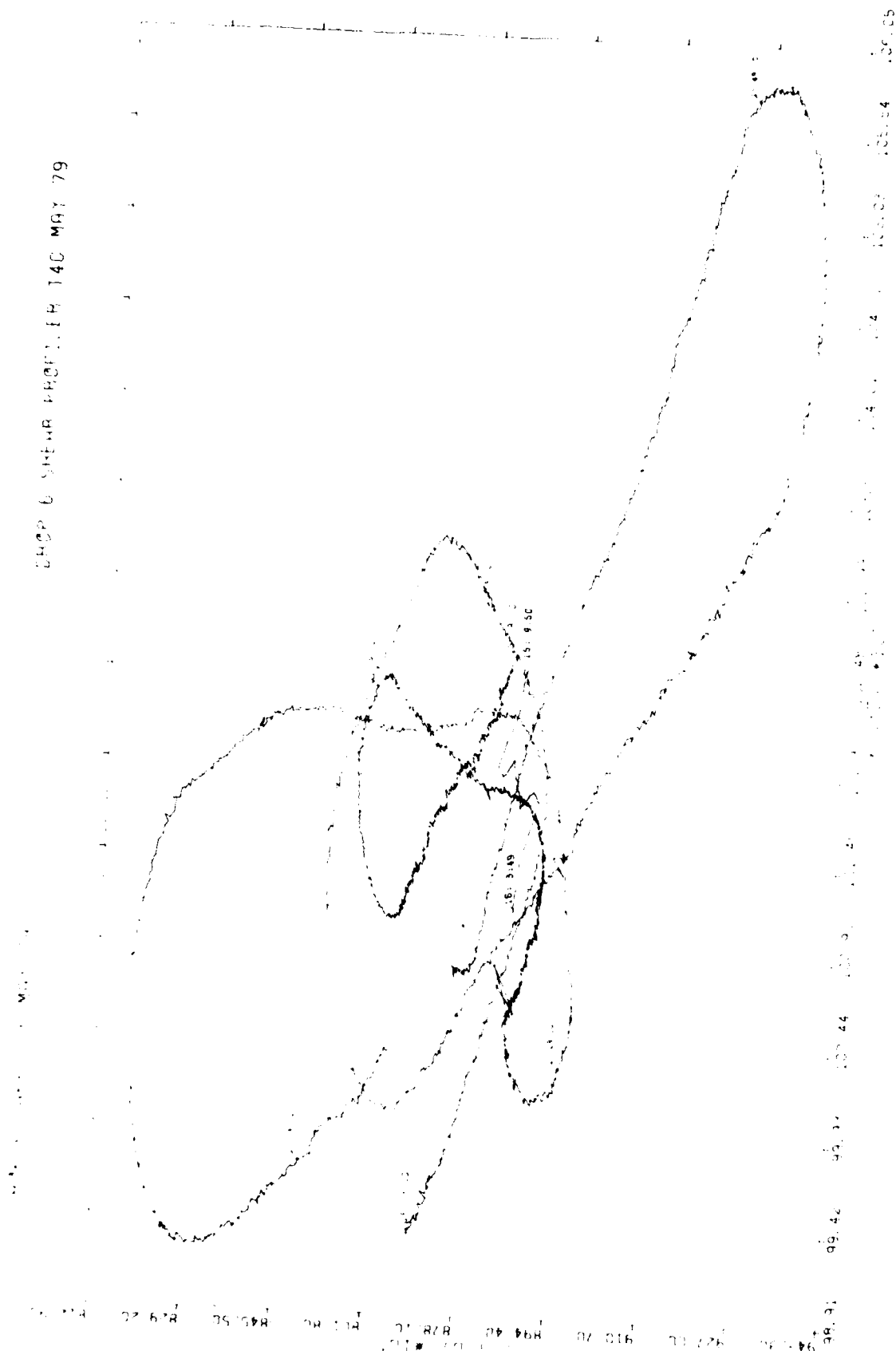


Figure 3d. East (X) and North (Y) trajectories of the R/V Cape and the APL/JHU profiler for Drop #6.

Page 136 May 1967

DROP 7 SHEAR PROFILER T40 MAY 79

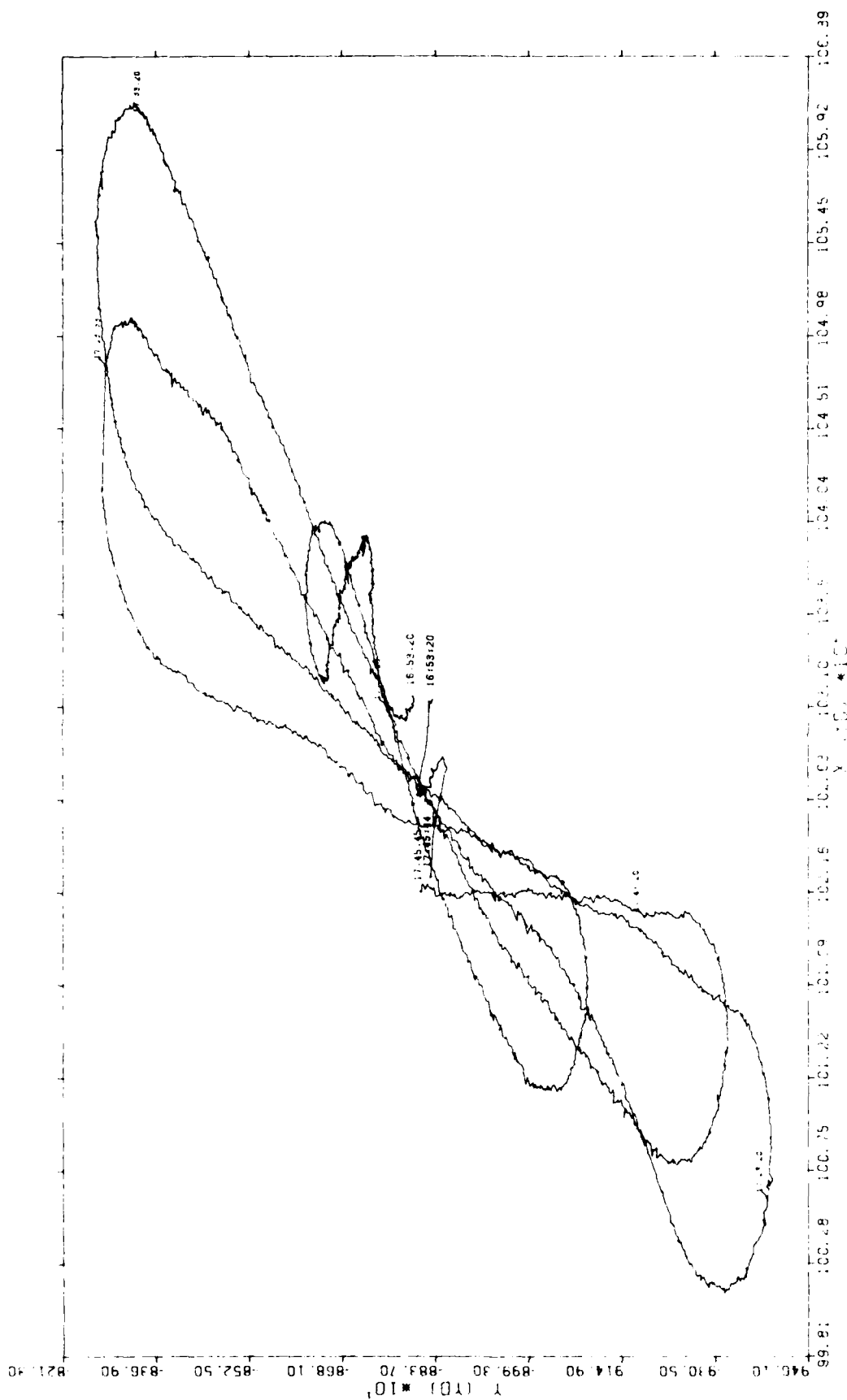


Figure 3e. East (X) and North (Y) trajectories of the R/V Cape and the APL/JHU profiler for Drop #7.

0000 8 CAFE 730 MG; '9

DATE 8 SEP 1954 PAGE 126 MAY 79

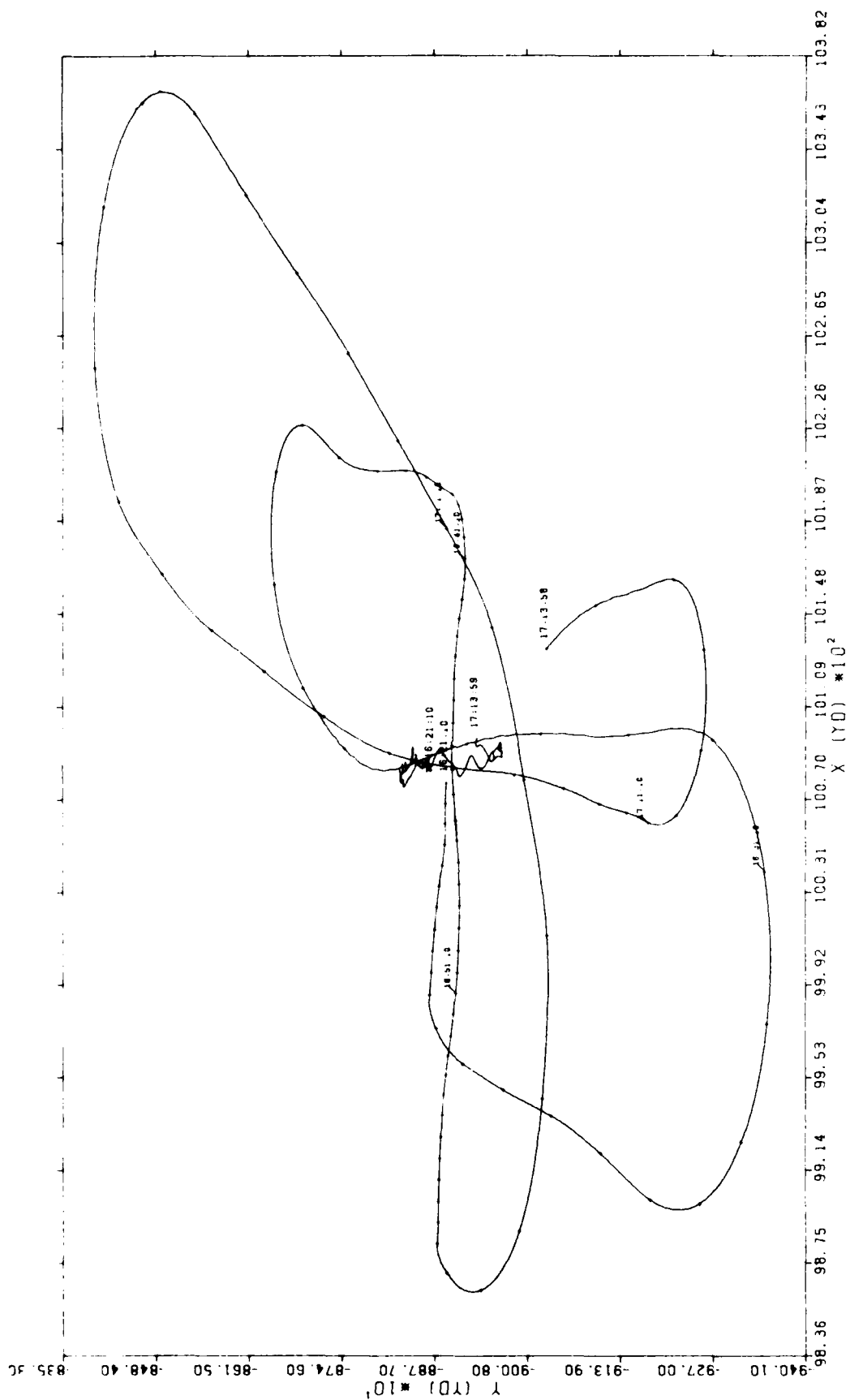


Figure 3f. East (X) and North (Y) trajectories of the RV Cape and the APL/JHU profiler for Drop #8.

DROP 9 SHEAR PROFILER 140 MAY 79

DROP 9 CAPE 130 MAY 79

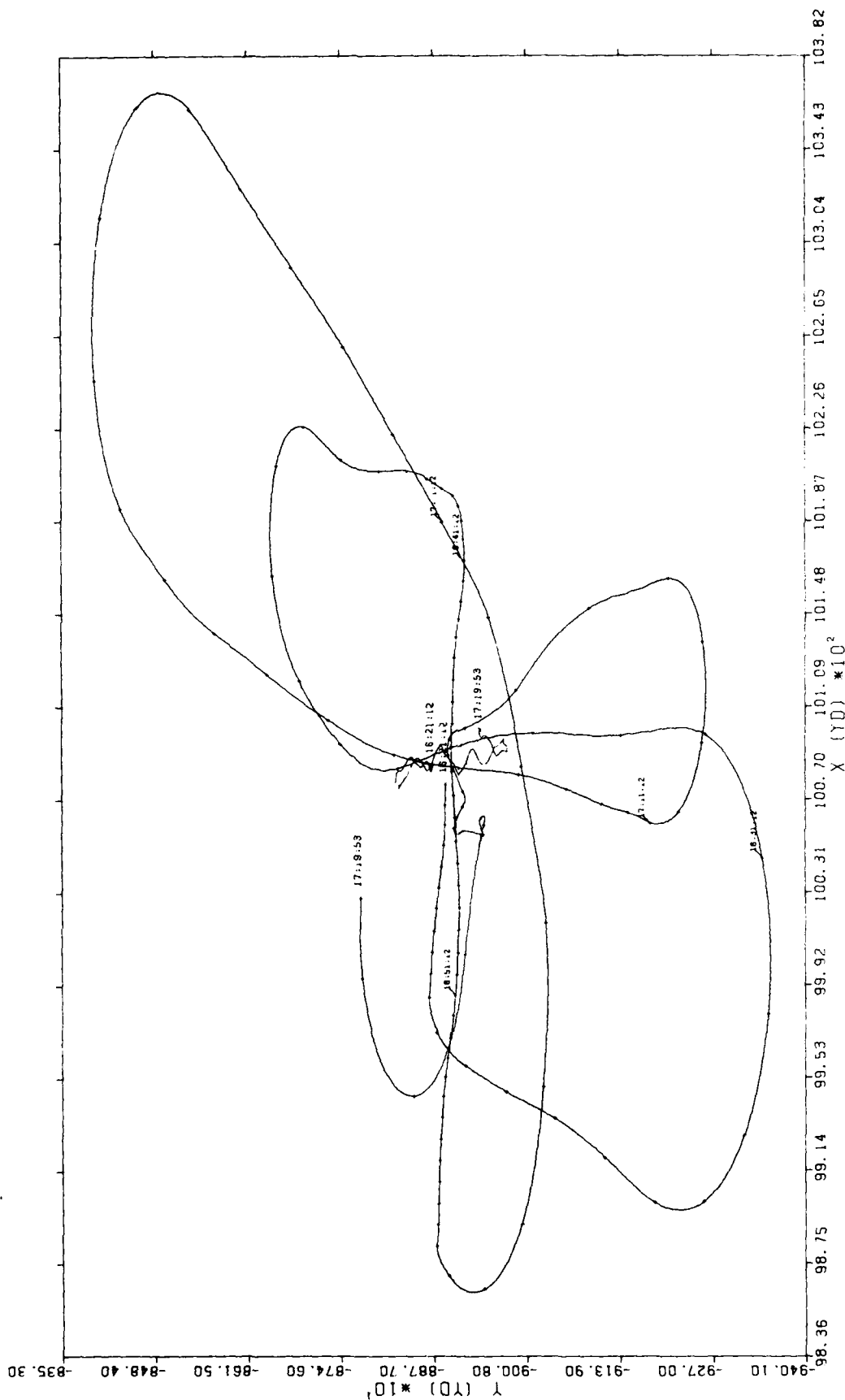
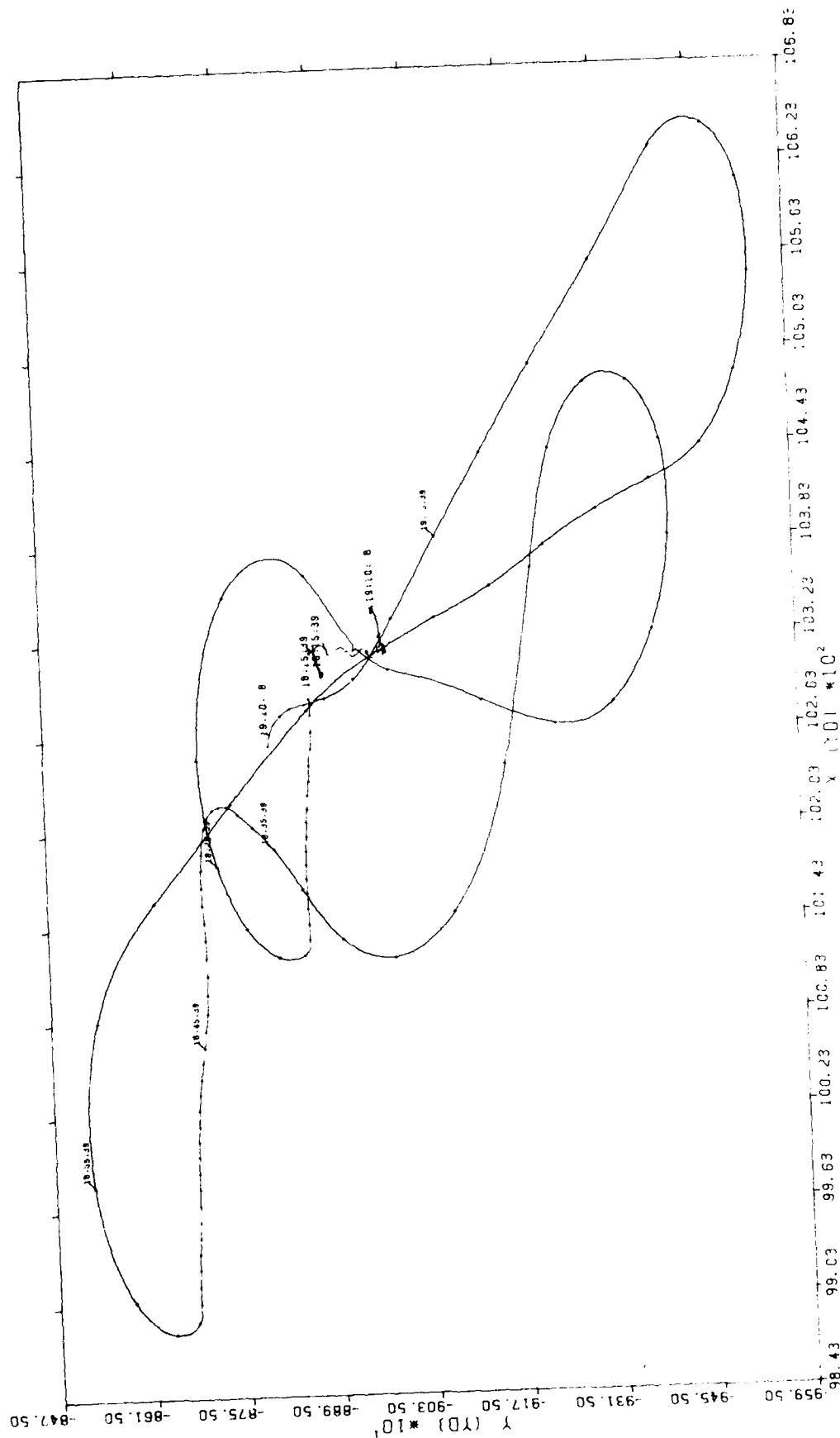


Figure 3g. East (X) and North (Y) trajectories of the R/V Cape and the APL/JHU profiler for Drop #9. 30.0 SECONDS BETWEEN MARKERS

DROP 10 SHEAR PROFILER 120 MAY 79

DROP 10 CAPE T30 MAY 79



30.0 SECONDS BETWEEN MARKERS

Figure 3h. East (X) and North (Y) trajectories of the R/V Cape and the APL/JHU profiler for Drop #10.

DROP 11 SHEAR PROFILER T40 MAY 79

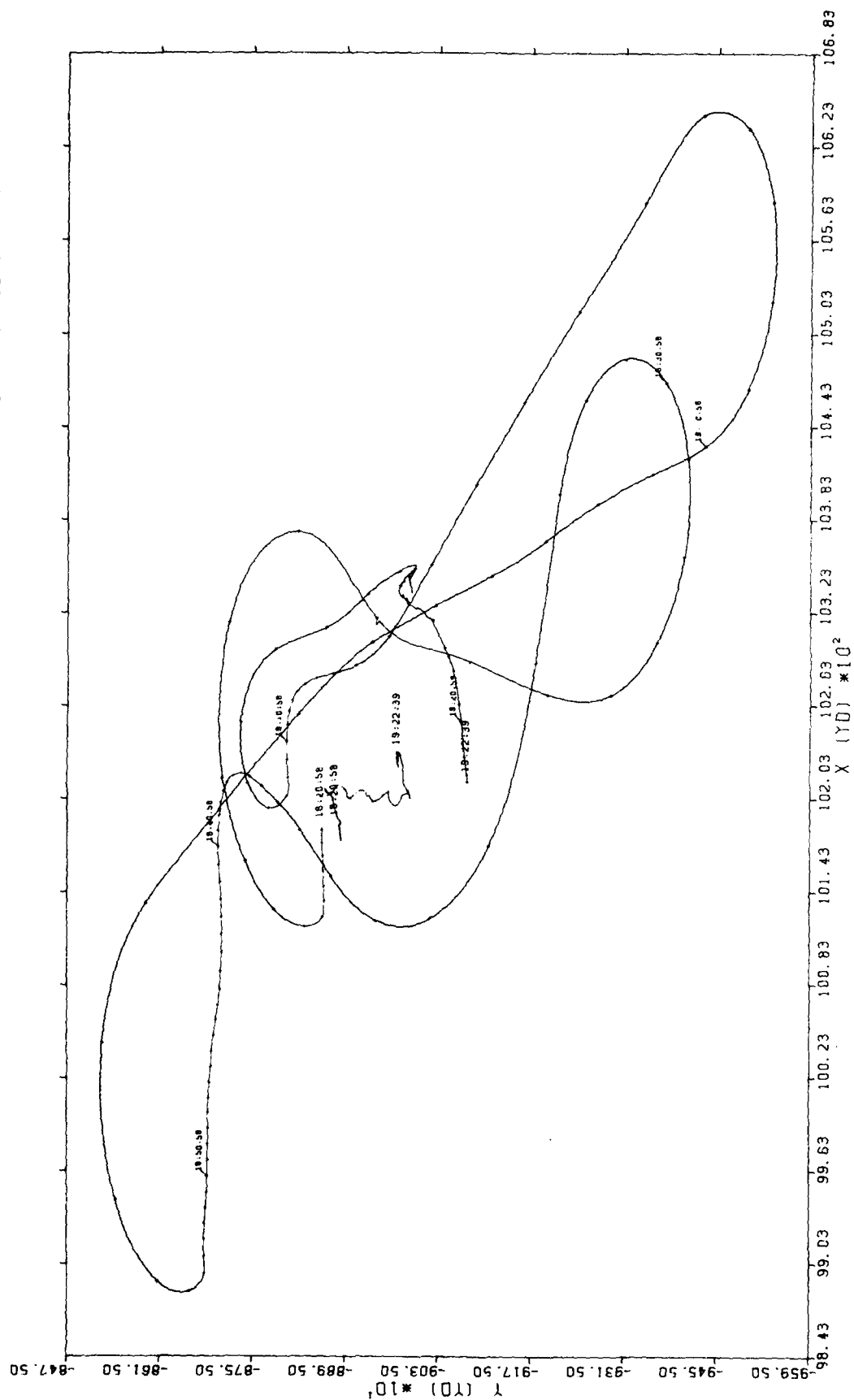


Figure 3i. East (X) and North (Y) trajectories of the R/V Cape and the APL/JHU profiler for Drop #11.

DRGP 12 CAPE 130 MAY 79

DROP 12 SHEAR PRJFILER T20 MAY 79

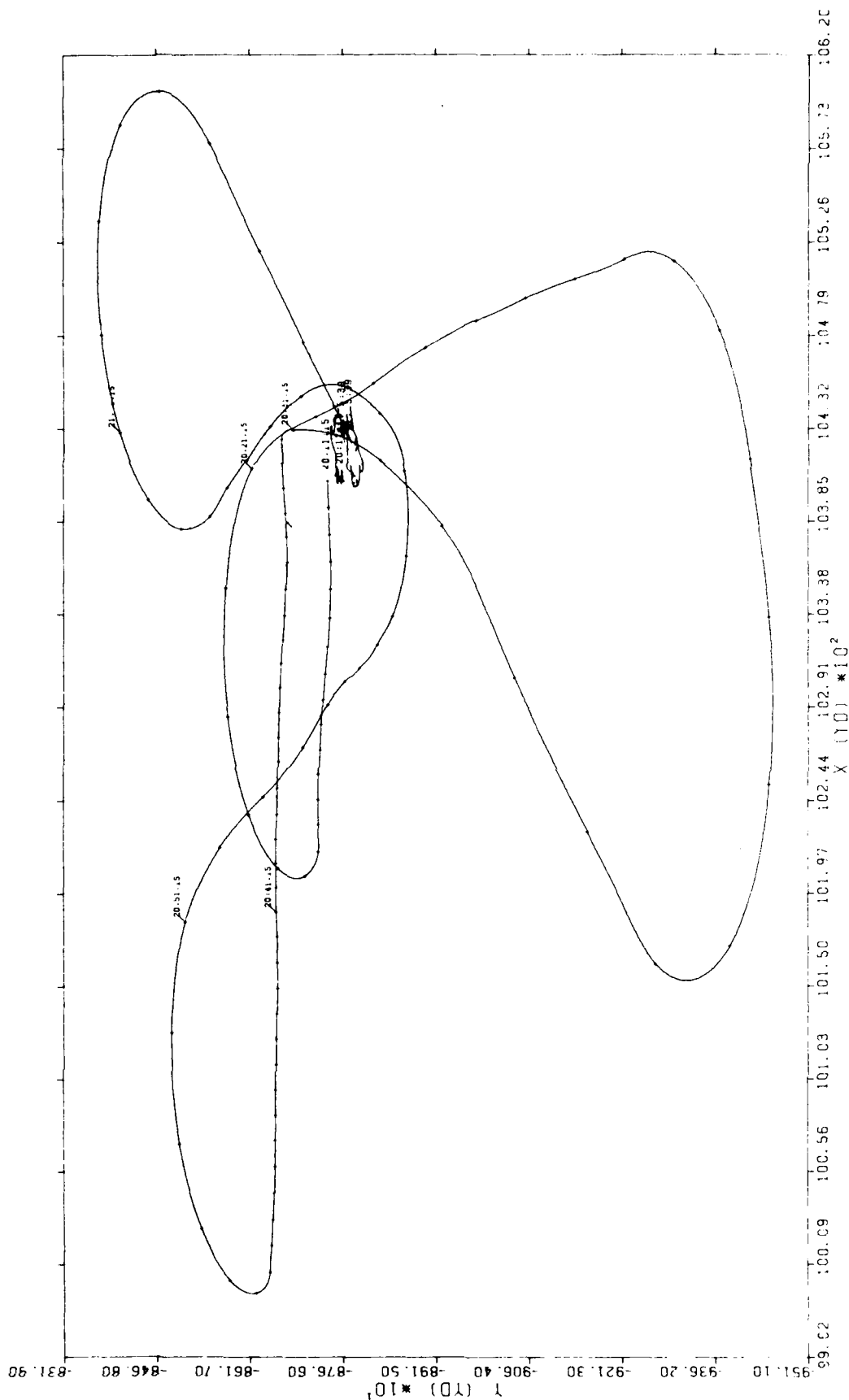
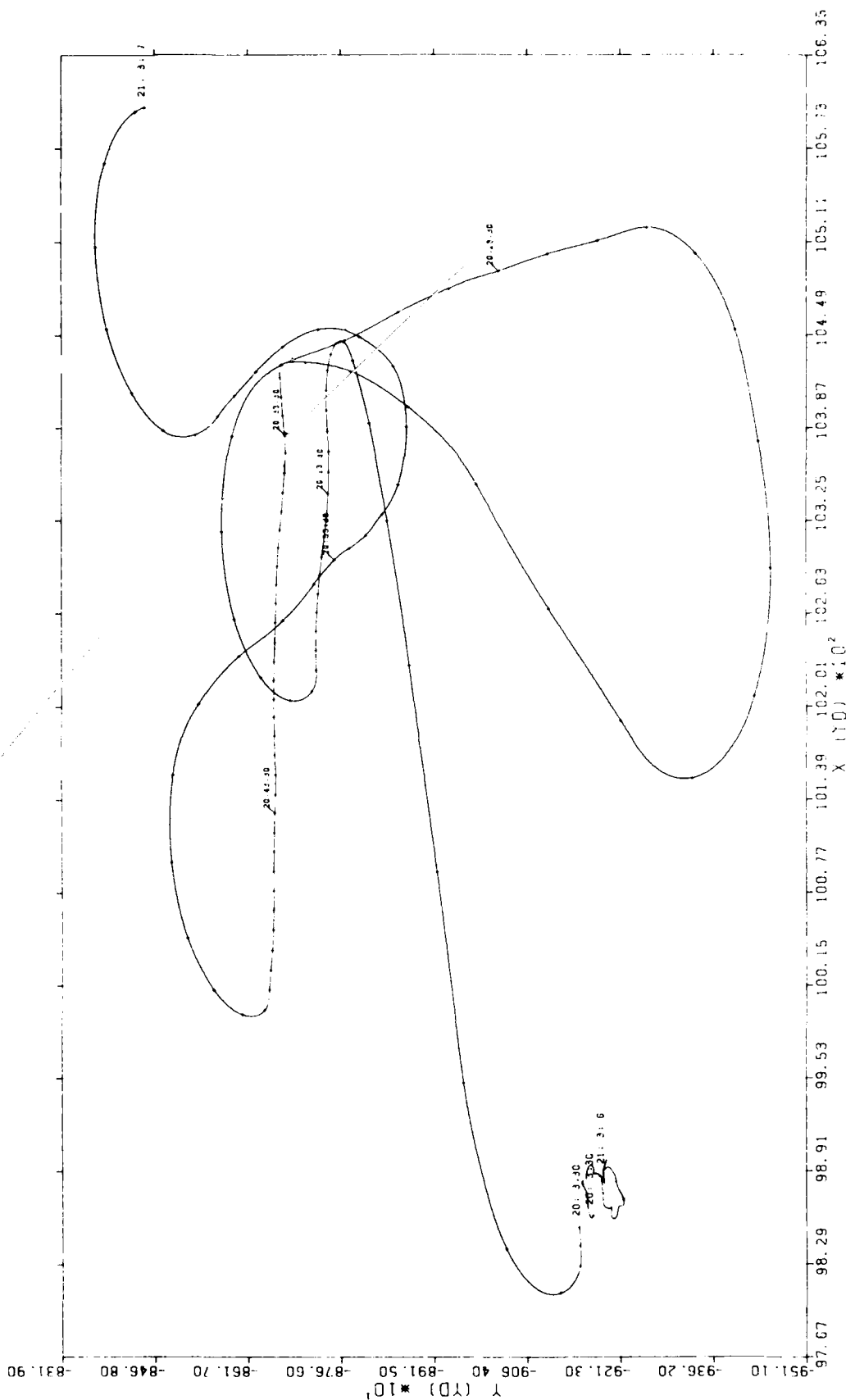


Figure 3j. East (X) and North (Y) trajectories of the R/V Cape and the APL/JHU profiler for Drop #12.

30.0 SECONDS BETWEEN MARKERS

DROP 13 CAPE 130 MAY 79

DROP 13 SHEAR PROFILER 140 MAY 79



30.0 SECONDS BETWEEN MARKERS

Figure 3k. East (X) and North (Y) trajectories of the R/V Cape and the APL/JHU profiler for Drop #13.

DROP 14 SHEAR PROFILER T20 MAY 79

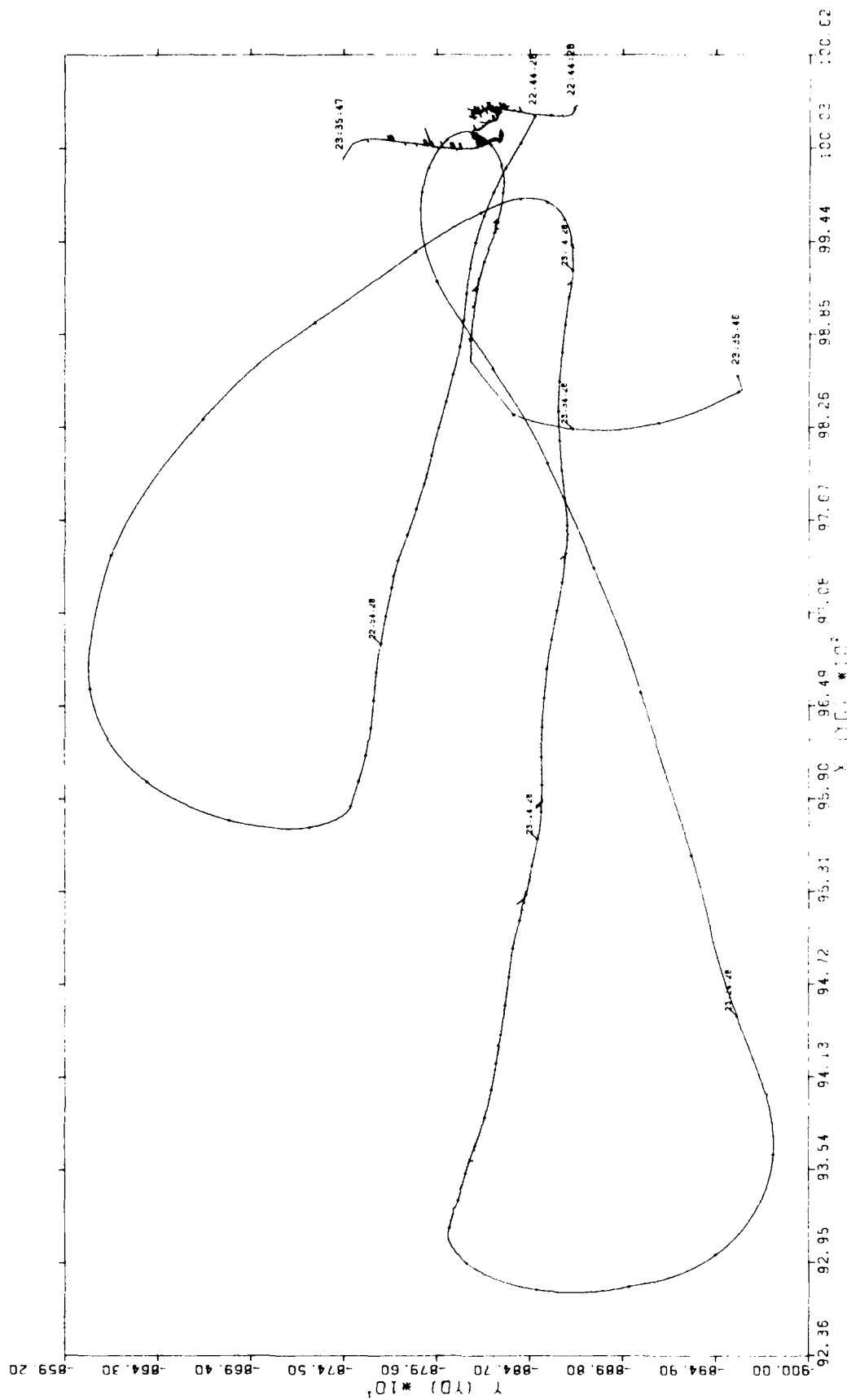
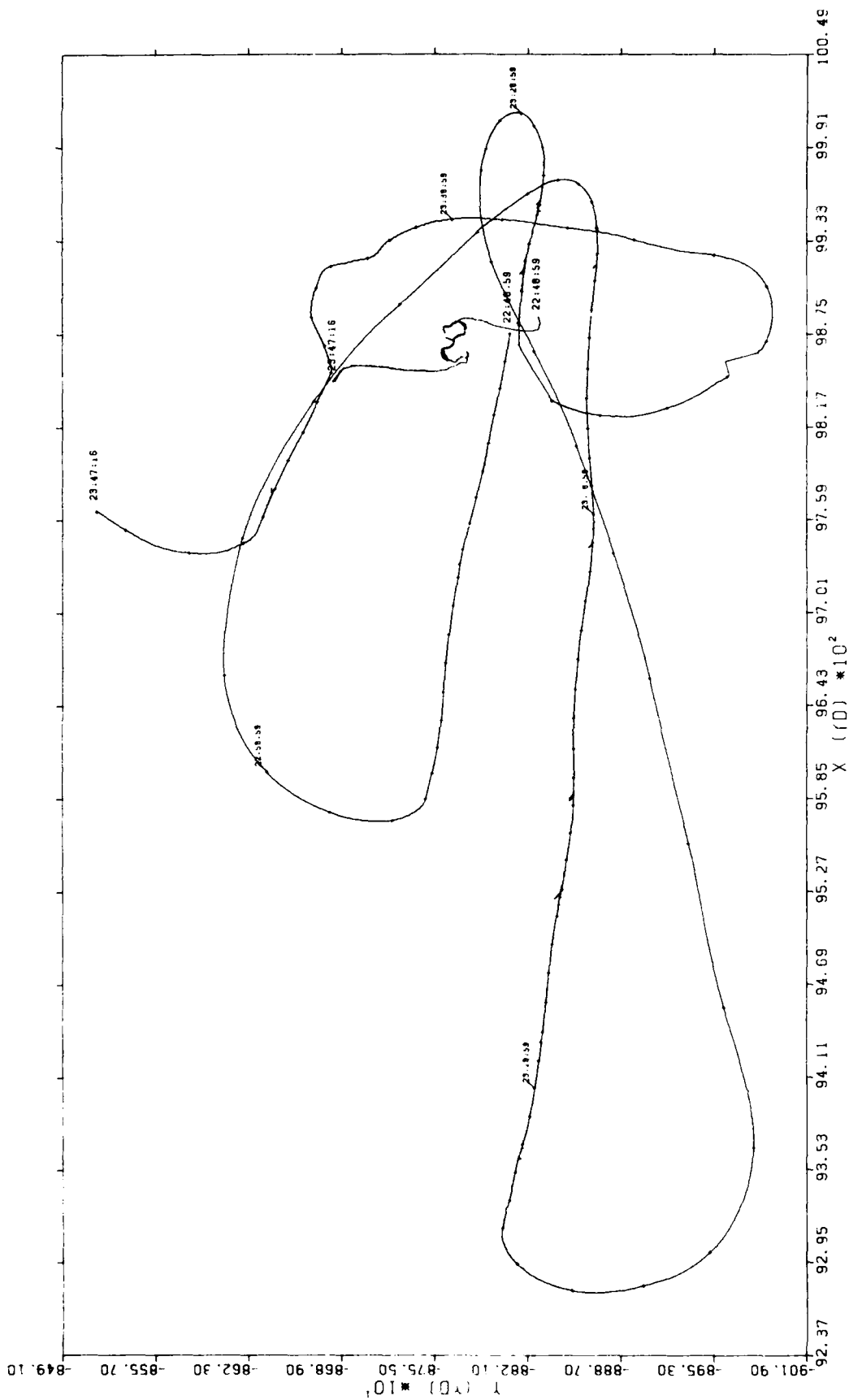


Figure 31. East (X) and North (Y) trajectories of the R/V Cape and the APL/JHU profiler for Drop #14.

DROP 15 CAPE T30 MAY 79

DROP 15 SHEAR PROFILER T40 MAY 79



30.0 SECONDS BETWEEN MARKERS

Figure 3m. East (X) and North (Y) trajectories of the R/V Cape and the APL/JHU profiler for Drop #15.

Table 2. Joint APL-UW and APL/JHU Observation Log

Obs. No.	Instrument Type & No.	Mod. No. & S/N	Date 1979	Start (z)	Stop (z)	Profiler		Comments
						Depth (yd)	Range (yd)	
1	CTD 201		8 May	003900	004530	NA	NA	200 dbar
2	CTD 202		8 May	010500	020500	NA	NA	160-190 dbar
3	XTVP 150	4-142	8 May	010900	011300	NA	NA	OK
4	XTVP 151	5-unkn	8 May	012600		NA	NA	NG: Shorted electrodes?
5	XTVP 152	unkn	8 May	013800		NA	NA	NG
6	CTD 203		8 May	021700	022545	NA	NA	240 dbar
6a	CTD 204		8 May	024200	034145	NA	NA	Yo-yo 160-190 dbar
7	XTVP 153	unkn	8 May	0250		NA	NA	NG
8	XTVP 154	5-045	8 May	0338	0342	NA	NA	OK
8a	CTD 205		8 May	034900	035805	NA	NA	240 dbar
9	APL/JHU #1		8 May	0749		---	---	175 m
10	XTVP 155	5-021	8 May	1159	1202	NA	NA	Lo compass coil; Hi in-phase component
11	CTD 206		8 May	125612	130355	NA	NA	240 dbar deep
12	APL/JHU #2		8 May	131826		---	---	175 m
13	XTVP 156	5-027	8 May	132415	132800	NA	NA	OK
14	XTVP 157	5-029	8 May	133145	133415	NA	NA	NG: Noisy
15	CTD 207		8 May	140100	140845	NA	NA	240 dbar
16	APL/JHU #3		8 May	142500	1445	---	---	160 m

Obs. No.	Instrument Type & No.	Mod. No. & S/N	Date	Start (z)	Stop (z)	Profiler Depth (yd)	Profiler Range (yd)	Comments
17	XTVP 158	5-040	1979 8 May	1428	143130	79	161	NG: Noisy
18	XTVP 159	5-049	8 May	144100	144445	48	75	NG
19	CTD 208		8 May	150400	151200	NA	NA	240 dbar
20	APL/JHU #4		8 May	152600	160634	---	---	360 m
21	XTVP 160	5-unkn	8 May	152630	153000	23	43	OK
22	XTVP 161	5-025	8 May	153445	153800	203	84	OK
23	XTVP 162	5-038	8 May	154230	154610	363	34	OK
24	XTVP 163	5-042	8 May	155450	155845	223	36	OK
25	XTVP 164	5-020	8 May	160215	160600	89	58	1st 80 s NG
26	CTD 209		8 May	165700	170525	NA	NA	240 dbar
27	APL/JHU #5		8 May	172156	181444	---	---	475 m
28	XTVP 165	4-195	8 May	173300	~1737	249	62	OK
29	XTVP 166	4-162	8 May	174305	174620	451	82	OK
30	XTVP 167	4-186	8 May	175330	175720	412	111	OK
31	XTVP 168	4-188	8 May	180435	180815	195	66	OK
32	XTVP 169	4-152	8 May	181230	181600	54	171	OK
33	CTD 210		8 May	184500	185230	NA	NA	240 dbar
34	APL/JHU #6		8 May	1910		---	---	490 m
35	XTVP 170	5-000	8 May	191030		27	37	Noise from 110-140 s
36	XTVP 171	4-115	8 May	192300	192630	299	54	OK

Obs. No.	Instrument Type & No.	Mod. No. & S/N	Date 1979	Start (z)	Stop (z)	Profiler Depth (yd)	Profiler Range (yd)	Comments
37	XTVP 172	5-026	8 May	193230	193630	491	76	NG: Strange
38	XTVP 173	5-028	8 May	194550	194904	338	84	OK
39	XTVP 174	5-046	8 May	200200	200540	44	70	OK
40	APL/JHU #7		8 May	205334	214540	---	---	470 m
41	XTVP 175	5-046	8 May	205500	205820	48	50	NG: Ground problem
42	XTVP 176	5-033	8 May	210930	211315	362	34	OK: Rubber boat
43	XTVP 177	5-036	8 May	211900	212245	503	31	OK: Rubber boat
44	XTVP 178	5-039	8 May	212830	213145	322	72	OK: Rubber boat
45	XTVP 179	5-041	8 May	213820	214205	141	43	OK: Rubber boat
46	XTVP 180	5-050	8 May	214545	214930	15	---	RF interference APL/JHU #7 snagged!
47	XTVP 181	4-190	8 May	233300		NA	NA	Shorted electrodes
48	XTVP 182	4-202	8 May	233800	234145	NA	NA	Shorted electrodes
49	XTVP 183	4-203	8 May	234230	234545	NA	NA	Shorted electrodes
50	XTVP 184	5-016	8 May	2349	235240	NA	NA	EF* preamp shorted
51	XTVP 185	5-017	8 May	235430	235810	NA	NA	EF preamp shorted
52	XTVP 186	5-018	9 May	000100	000440	NA	NA	Shorted
53	XTVP 187	5-052	9 May	000700	001040	NA	NA	OK: Big shear
54	XTVP 188	5-051	9 May	001330	0017	NA	NA	OK: Big shear
55	XTVP 189	5-044	9 May	0024	002825	NA	NA	Noisy: Underway
56	XTVP 190	5-048	9 May	003100	003415	NA	NA	NG: 11 knots
57	CTD 211		10 May	193800	194550	NA	NA	240 dbar

* EF = electric field

Obs. No.	Instrument Type & No.	Mod. No. & S/N	Date 1979	Start (z)	Stop (z)	Profiler Depth (yd)	Profiler Range (yd)	Comments
58	XTVP 191	4-220	10 May	195400	195730	NA	NA	OK: 1978 vintage
59	APL/JHU #8		10 May	202110	211358	---	---	490 m
60	APL/JHU #9		10 May	202112	211953	---	---	480 m
61	XTVP 192	5-035	10 May	202200	202540	31	30	OK
62	XTVP 193	4-144	10 May	202200	202530	31	30	NG
63	XTVP 194	5-012	10 May	203400	203730	255	53	Noisy
64	XTVP 195	4-237	10 May	203400	203730	255	53	OK: Pressure
65	CTD 212		10 May	204009	205505	NA	NA	400 dbar
66	XTVP 196		10 May	205020	205400	523	82	NG
67	XTVP 197	5-032	10 May	210000	210515	353	74	Blunt nose; 4 Hz
68	XTVP 198	4-187	10 May	210900	211230	198	18	OK: 1978 vintage
69	XTVP 199	4-239	10 May	221625	222000	NA	NA	EF NG, but pressure OK
70	XTVP 200	4-222	10 May	221625	222000	NA	NA	OK
71	APL/JHU #10		10 May	221539	231008	---	---	490 m
72	APL/JHU #11		10 May	222058	232239	---	---	500 m
73	XTVP 201	4-236	10 May	223530	223910	283	56	OK: Pressure; in-phase trend
74	XTVP 202	4-226	10 May	223530	223910	283	56	OK: 1978 vintage
75	CTD 213		10 May	223840	225050	NA	NA	400 dbar
76	XTVP 203	4-233	10 May	225830	230158	425	146	OK: Pressure
77	XTVP 204	4-231	10 May	225830	230150	425	146	OK: 1978 vintage
78	XTVP 205	4-238	10 May	230645	231013	282	102	OK: Pressure
79	XTVP 206	4-234	10 May	230645	231013	282	102	OK: 1978 vintage
80	APL/JHU #13		11 May	000330	010306	---	---	480 m

Obs. No.	Instrument Type & No.	Mod. No. & S/N	Date	Start (z)	Stop (z)	Profiler Depth (yd)	Profiler Range (yd)	Comments
81	APL/JHU #12		11 May 1979	001115	010539	---	---	500 m
82	XTVP 207	4-179	11 May	002230	002515	259	114	Wobble: Pressure; 15° fins
83	XTVP 208	4-166	11 May	002230	002515	259	114	Wobble: Pressure; 10° fins
84	CTD 214		11 May	003500	004650	NA	NA	400 dbar
85	XTVP 209	4-230	11 May	003705	004000	551	168	Wobble: Pressure; 15° fins
86	XTVP 210	4-163	11 May	003705	004000	551	168	Wobble: Pressure; 20° fins
87	XTVP 211	4-164	11 May	005720	010030	159	57	Some wobble; pressure, 20° fins
88	XTVP 212	4-167	11 May	005720	010030	159	57	Wobble: Pressure; 10° fins
89	APL/JHU #14	Big	11 May	024430	033547	---	---	460 m
90	APL/JHU #15	Small	11 May	024856	034716	---	---	480 m
91	XTVP 213	5-019	11 May	025000	025440	34	46	NG: Blunt nose
92	XTVP 214	5-023	11 May	030245	030730	271	125	NG: Blunt nose
93	CTD 215		11 May	030700		NA	NA	400 dbar
94	XTVP 215	4-240	11 May	032840	033220	335	157	OK: Pressure
95	CTD		11 May			NA	NA	Perhaps a yo-yo
96	XTVP 216	5-006	11 May	054630	055000	NA	NA	NG: Pressure
97	XTVP 217	4-153	11 May	061000	061330	NA	NA	OK
98	XTVP 218	4-228	11 May	063000	063320	NA	NA	OK
99	XTVP 219	4-232	11 May	065000	065320	NA	NA	OK: Big shear
100	XTVP 220	4-235	11 May	071200	071525	NA	NA	OK: Big shear

Table 3. R/V Cape and APL/JHU Profiler Positions at Times of XTVP Deployments

APL/JHU PROFILER NO.	XTVP DROP NO.	TIME	R/V Cape (yd)			APL/JHU Profiler (yd)			Range (yd) R
			x (+)	y (-)	z (-)	x (+)	y (-)	z (+)	
4	160	-10	10219.92	8696.63	45.86	10223.94	8733.90	19.01	37.49
		152630	10217.22	8689.95	45.85	10222.30	8732.48	22.74	42.83
		+10	10213.54	8682.51	45.84	10220.82	8731.01	26.49	49.05
4	161	-10	10112.45	8626.97	45.65	10165.34	8647.92	199.31	56.98
		153445	10085.24	8619.07	45.61	10164.95	8646.38	202.93	84.26
		+10	10056.32	8605.26	45.56	10164.79	8645.07	206.55	115.55
4	162	-10	10140.18	8668.51	45.73	10159.96	8652.97	359.58	25.15
		154230	10148.76	8685.88	45.76	10159.61	8653.79	362.82	33.88
		+10	10157.33	8703.26	45.79	10159.01	8654.57	366.19	48.72
4	163	-10	10136.75	8674.87	45.73	10147.06	8676.31	225.34	10.41
		155450	10121.28	8700.45	45.74	10146.69	8675.43	222.35	35.67
		+10	10107.99	8723.24	45.74	10146.29	8674.55	219.07	61.95
4	164	-10	10099.54	8568.61	45.58	10113.74	8596.08	91.50	30.93
		160215	10096.70	8537.83	45.55	10112.38	8593.88	88.60	58.21
		+10	10092.62	8510.62	45.52	10111.00	8591.96	85.72	83.38
5	165	-10	10037.91	8712.93	45.64	10061.83	8686.05	245.70	35.98
		173300	10030.46	8740.31	45.65	10061.45	8686.29	249.27	62.28
		+10	10031.33	8765.27	45.68	10061.23	8687.12	252.72	83.67
5	166	-10	10079.15	8648.94	45.63	10060.81	8707.98	448.12	61.82
		174305	10094.32	8633.78	45.64	10060.72	8708.18	451.37	81.63
		+10	10112.43	8620.93	45.65	10060.71	8708.39	454.74	101.61
5	167	-10	9948.72	8726.43	45.53	10050.96	8729.30	415.33	102.28
		175330	9939.91	8725.43	45.52	10050.91	8729.64	412.11	111.07
		+10	9926.44	8728.24	45.50	10050.74	8730.19	408.63	124.32
5	168	-10	10085.45	8717.45	45.70	10048.41	8746.45	197.56	47.04
		180435	10108.49	8720.60	45.74	10047.84	8745.52	194.51	65.57
		+10	10122.43	8733.20	45.77	10047.37	8744.41	191.34	75.90
5	169	-10	10063.85	8527.03	45.49	9998.16	8684.84	54.12	170.93
		181230	10074.34	8521.77	45.50	9996.30	8683.71	51.05	179.76
		+10	10081.15	8515.12	45.50	9994.26	8682.52	48.21	188.60
6	170	-10	10244.30	8833.04	46.03	10250.29	8867.71	23.29	35.18
		191030	10243.09	8830.55	46.02	10249.91	8866.78	26.95	36.87
		+10	10240.66	8825.56	46.02	10249.47	8866.57	30.47	41.94
6	171	-10	10177.28	8885.03	45.99	10194.30	8838.78	295.37	49.29
		192300	10174.30	8888.76	45.99	10194.35	8838.90	298.84	53.74
		+10	10169.82	8894.36	45.99	10194.73	8839.29	302.14	60.44
6	172	-10	10231.14	8813.43	45.99	10195.49	8855.01	487.53	54.77
		193230	10229.29	8787.59	45.96	10195.13	8855.21	490.63	75.77
		+10	10222.26	8762.24	45.93	10194.51	8855.44	494.02	97.25

APL/JHU PROFILER NO.	XTVP DROP NO.	TIME	R/V Cane (yd)			APL/JHU Profiler (yd)			RANGE (yd) R
			x (+)	y (-)	z (-)	x (+)	y (-)	z (+)	
6	173	-10	10239.61	8901.16	46.09	10177.52	8871.11	341.13	68.97
		*194550	10250.30	8915.82	46.11	10178.01	8872.18	337.98	84.44
		+10	10263.17	8933.76	46.15	10178.32	8873.44	334.67	104.10
6	174	-10	10083.28	8846.41	45.83	10128.69	8863.84	47.02	48.65
		200200	10066.74	8827.06	45.79	10126.24	8863.27	44.25	69.65
		+10	10047.70	8814.84	45.75	10123.65	8862.69	41.38	89.77
7	175	-10	10332.19	8737.94	46.05	10307.88	8825.61	44.42	90.98
		205500	10342.77	8732.56	46.06	10305.57	8825.29	48.09	99.91
		+10	10352.37	8732.49	46.07	10303.45	8825.05	51.82	104.69
7	176	-10	10254.20	8766.20	45.98	10269.39	8829.24	358.55	64.84
		210930	10260.88	8745.63	45.97	10269.16	8829.62	361.96	84.40
		+10	10268.05	8716.35	45.95	10269.22	8829.66	365.33	113.32
7	177	-10	10238.09	8876.99	46.06	10274.31	8831.80	506.15	57.91
		211900	10228.80	8898.66	46.07	10274.50	8832.04	503.04	80.78
		+10	10222.19	8920.95	46.08	10274.61	8832.27	499.88	103.02
7	178	-10	10290.88	8741.92	46.00	10277.60	8836.64	325.13	95.65
		212830	10298.77	8717.74	45.99	10277.71	8837.47	321.97	121.57
		+10	10307.12	8690.91	45.97	10277.92	8838.14	318.78	150.09
7	179	-10	10218.52	8893.51	46.05	10268.72	8848.00	143.87	67.76
		213820	10205.02	8916.40	46.06	10267.88	8847.58	140.96	93.22
		+10	10196.21	8935.41	46.06	10266.98	8847.18	138.02	113.11
7	180	-10	10217.02	8831.19	45.99	10224.18	8828.08	16.68	7.80
		214545	10216.15	8812.20	45.97	10223.10	8827.45	15.40	**16.76
		+10	(none)						
8		-10	(none)						
		202110	10077.06	8894.23	16.37	10082.68	8873.96	16.04	21.04
		+10	10073.96	8893.60	16.59	10081.29	8873.04	20.34	21.83
9		-10	(none)						
		202110	10076.41	8893.98	16.52	10084.43	8875.28	16.12	20.39
		+10	10073.31	8893.99	16.28	10081.92	8874.24	18.70	21.04
9	192	-10	10065.11	8892.84	16.41	10082.57	8872.17	27.88	27.06
		202200	10062.34	8892.60	16.44	10083.23	8871.72	31.47	29.53
		+10	10059.50	8892.43	16.39	10083.96	8871.29	34.43	32.28

* Time from observation log. Note: time may be 194530 (XTVP log).

** APL/JHU #7 snagged.

APL/JHU PROFILER NO.	XTVP DROP NO.	TIME	R/V Cape (yd)			APL/JHU Profiler (yd)			Range (yd)	
			x (+)	y (-)	z (-)	x (+)	y (-)	z (+)	R	
9	193	Same as 192								
9	194	-10	10081.99	8803.52	16.49	10075.74	8828.17	252.22	24.14	NG
		203400	10084.80	8776.06	16.62	10075.18	8828.24	255.27	53.06	
		+10	10091.53	8750.90	16.20	10074.57	8828.14	258.40	77.92	
9	195	Same as 194								
9	196	-10	10006.20	8910.93	16.53	10085.25	8903.04	525.55	79.29	
		205020	10003.13	8910.46	16.51	10084.89	8904.01	522.97	81.90	
		+10	10000.03	8910.02	16.28	10084.62	8905.00	520.11	84.74	
9	197	-10	10035.42	9027.99	16.93	10084.41	8946.86	355.86	95.68	
		210000	10056.24	9016.60	16.60	10084.53	8947.76	352.80	74.43	
		+10	10078.68	9003.62	16.73	10084.41	8949.13	350.42	54.79	
9	198	-10	10082.33	8934.03	16.16	10089.69	8979.52	200.48	46.08	
		210900	10081.61	8962.69	16.48	10089.91	8978.77	197.50	18.09	
		+10	10080.38	8990.70	16.59	10090.06	8977.93	194.59	16.02	
9	199	-10 221625 +10	Data not available.							
9	200	Data not available.								
11	201	-10	10175.33	8837.35	16.20	10206.63	8873.89	276.66	47.79	
		223530	10183.88	8823.74	16.29	10206.84	8874.97	282.69	56.14	
		+10	10191.40	8811.19	16.04	10206.94	8875.73	285.72	65.30	
11	202	Same as 201								
11	203	-10	10321.48	9004.01	16.63	10205.78	8954.13	427.77	125.08	
		225830	10328.65	9034.76	16.74	10205.93	8954.79	424.86	145.61	
		+10	10335.47	9064.32	16.69	10206.17	8955.46	421.86	166.93	
11	204	Same as 203								
11	205	-10	10299.93	8946.88	16.57	10204.72	8980.27	285.00	101.04	
		230645	10293.05	8929.43	16.70	10204.90	8980.74	281.94	101.85	
		+10	10288.81	8913.87	16.54	10205.06	8981.45	279.29	107.31	
11	206	Same as 205								
12	207	-10	10458.42	8830.15	16.79	10428.69	8746.55	255.56	86.07	
		002230	10464.64	8857.26	16.86	10429.25	8747.03	258.88	114.45	
		+10	10470.51	8885.21	16.53	10429.77	8748.13	262.42	141.75	
12	208	Same as 207								
12	209	-10	10296.33	8665.02	16.38	10420.69	8773.47	547.53	164.63	
		003705	10292.22	8664.68	16.69	10420.36	8773.30	550.97	167.88	
		+10	10288.05	8664.27	16.36	10420.15	8773.21	554.00	171.02	

APL/JHU PROFILER NO.	XTVP DROP NO.	TIME	R/V Cape (yd)			APL/JHU Profiler (yd)			Range (yd) R
			x (+)	y (-)	z (-)	x (+)	y (-)	z (+)	
12	210	Same as 209							
		-10	10452.52	8775.54	16.91	10416.36	8796.23	162.11	41.66
12	211	005720	10454.05	8752.90	17.02	10416.79	8795.76	158.93	56.79
		+10	10453.25	8732.01	16.69	10417.15	8795.39	156.06	72.94
12	212	Same as 211							
		-10	9846.58	8802.46	17.14	9878.62	8828.70	31.45	11.15
15	213	025000	9841.03	8801.01	16.82	9878.05	8828.08	31.34	15.86
		+10	9835.54	8799.63	16.94	9877.83	8827.27	37.76	50.30
		-10	9971.52	8845.70	17.06	9879.94	8763.91	267.92	122.68
15	214	030245	9970.90	8850.90	17.09	9879.61	8764.86	270.95	125.27
		+10	9969.44	8855.11	17.12	9879.37	8765.40	274.09	127.12
		-10	10008.91	8801.66	17.25	9862.55	8761.58	338.36	151.53
15	215	032840	10012.46	8807.26	17.00	9861.98	8761.77	335.48	157.01
		+10	10013.24	8812.07	17.34	9861.60	8761.88	332.37	159.65
15	216	054630	Data not available.						
		+10							

IV. OBSERVATIONS

The APL/JHU velocity profiles are presented in Figures 4a through 4o in which the line for the descent portion is about half the width of the line for ascent. Dr. Wenstrand points out that APL/JHU drops 14 and 15 contain several instances of error caused when the tracking computer switched between different hydrophone arrays. This switching was allowed because certain hydrophone combinations yield better signal strengths, but it produces small discontinuities in position determination and spikes in computed velocity. This problem seems somewhat more severe in drop 14, and so drop 15 was used for intercomparison purposes.

The profiles in Figures 4a-4o were digitized on an HP9874A digitizer coupled to an HP9845S computer. The digitized versions of the APL/JHU profiles were plotted on an HP9872A plotter and compared with the originals. The rms difference between the original and digitized version was less than 0.2 cm/s.

The processing procedure followed in the treatment of the XTVP data was as follows:

1. The analog tapes were replayed so that all variables were measured and plotted on the analog plotter. The playback system is depicted in Figure 5. The analog plots consisted of I (in-phase) and Q (quadrature-phase) for electric field, and I and Q for compass coil; on the third plot, there were graphs of temperature and rotation period.
2. The analog plots were digitized by hand with the 9874A digitizer connected to the 9845S computer. The work was done under the control of the program DIGITZ.
3. The digitized variables were plotted by DIGITZ on the 9872A plotter with the same scaling as the original so that digitized and original versions could be overlaid for comparison and error detection.
4. The raw digitized profiles were processed using the calibration factors and known corrections by program XPROC. This program also deconvolves the profile to eliminate the effect of the analog filter in the PAR 129 lock-in amplifier (Fig. 5) and filters to a scale similar to that of the APL/JHU profiles.
5. The final processed profiles were plotted by XPROC on the 9872A and stored in a flexible disk.

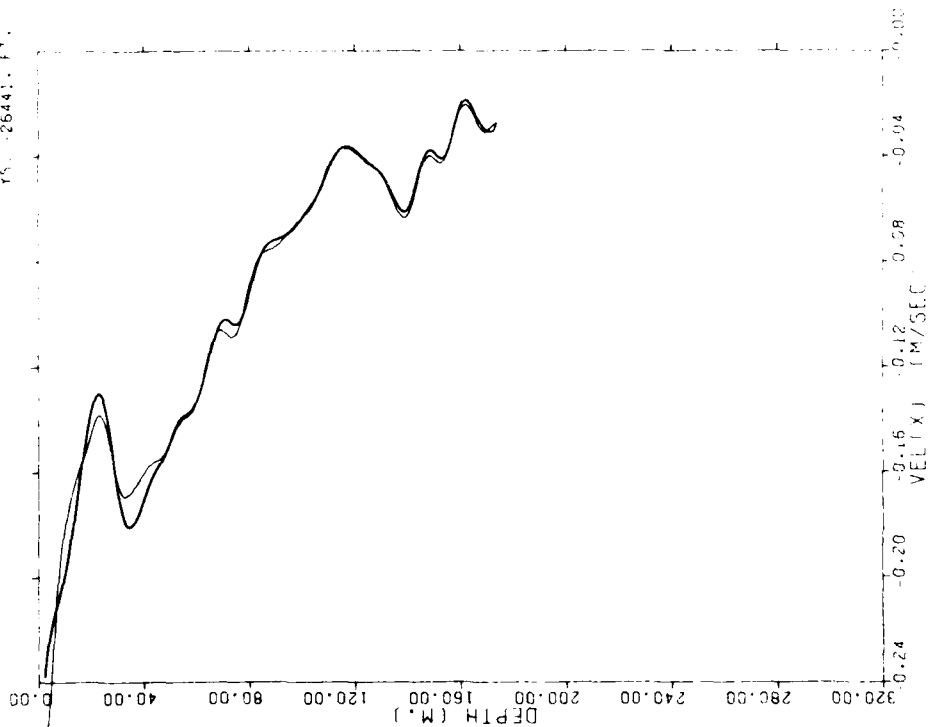
Portions of some profiles are missing due to probe malfunction (e.g., several gaps in XP170g, Figure 6c) or have been deleted because of interference from the electric and magnetic fields around the research vessel. Since most of the probes were released from the vessel, the uppermost portion (about 100 m) of the profile has been deleted.

DROP 1 140 AUTEC MAY 79

DZ = 7.0 M.

DESCENT
ASCENT

ZRGD 0.00 M.
ZOFF 13.00 M.
XS 71491.0 LOCAL
YS 30434.1 FT.
ZS 126441. FT.



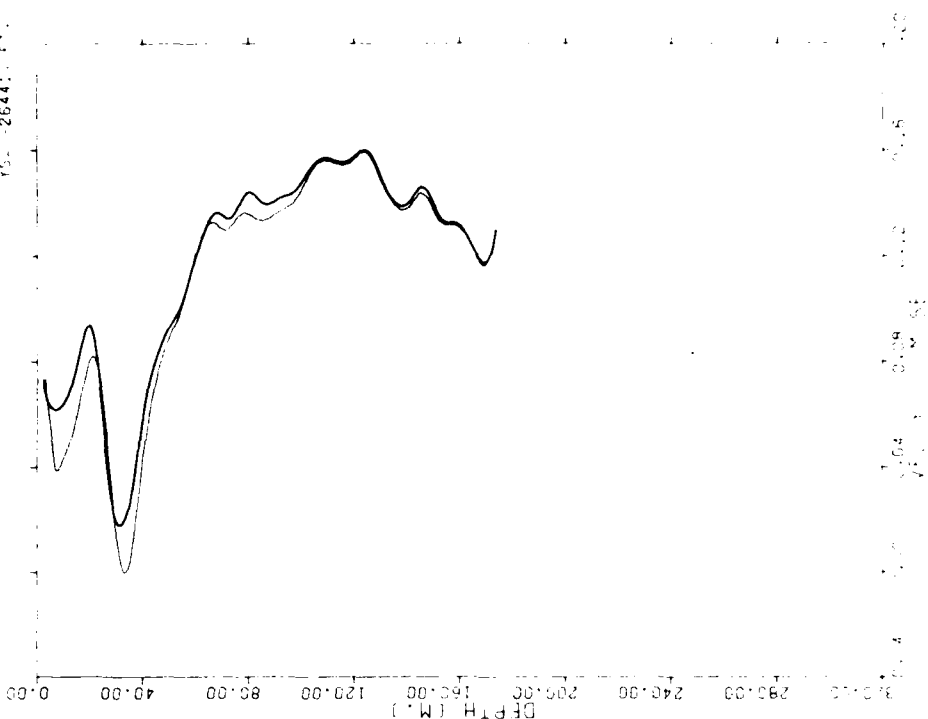
PROCESSID: 08:27:38 13-JUL-79

DROP 1 140 AUTEC MAY 79

DZ = 7.0 M.

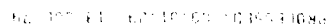
DESCENT
ASCENT

ZRGD 0.00 M.
ZOFF 13.00 M.
XS 71491.0 LOCAL
YS 30434.1 FT.
ZS 126441. FT.



PROCESSID: 09:27:38 13-JUL-79

Figure 1a. APL/JIU Drop #1: Profiles of East (VEL(X)) and North (VEL(Y)) velocity components as computed and plotted by P. Wenstrand. Thicker line is as profiler ascends.



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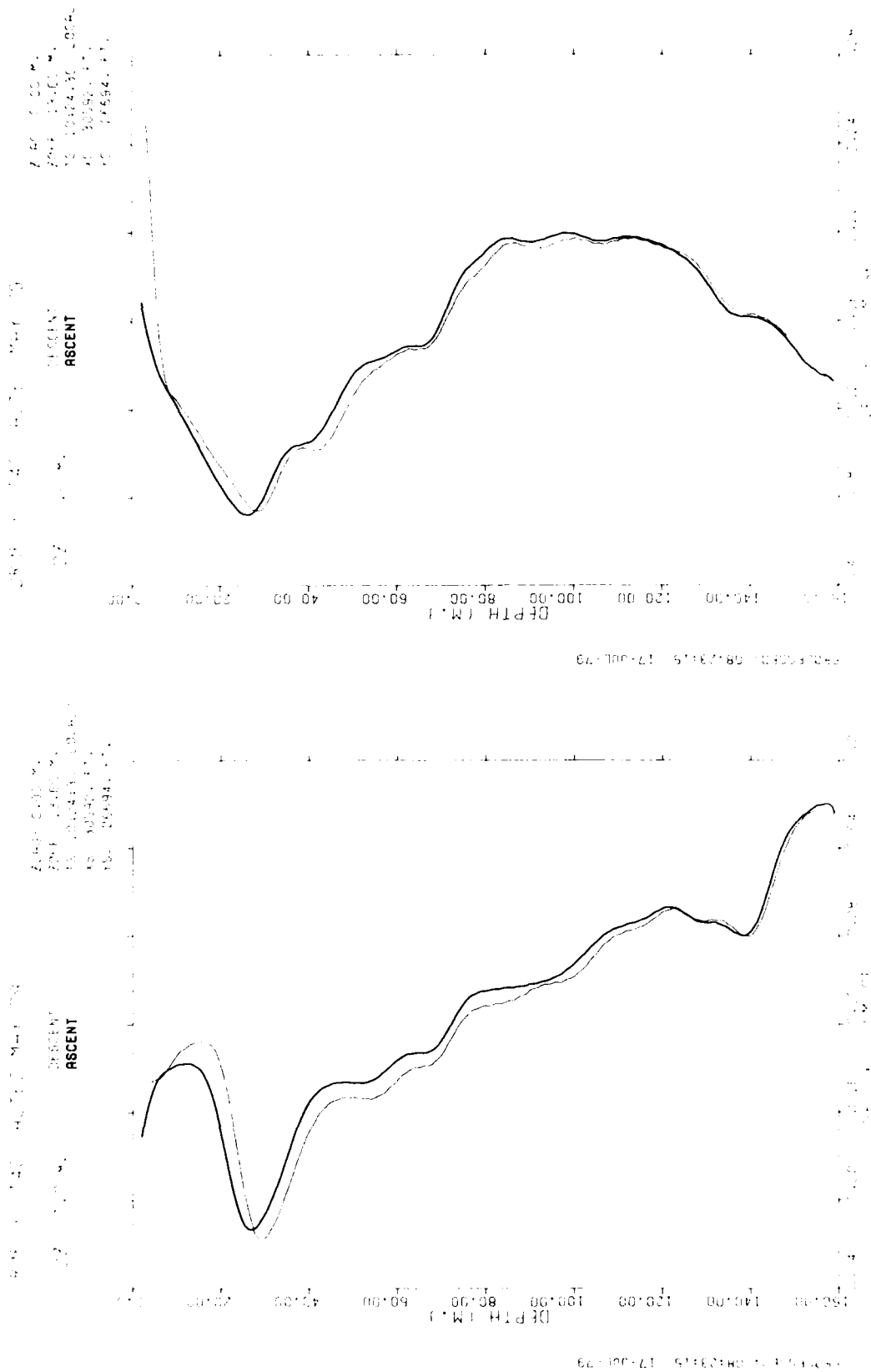


Figure 4c. APL/JHU Drop #5: Profiles of East (VEL(X)) and North (VEL(Y)) velocity components as computed and plotted by D. Wenstrand. Thicker line is as profiler ascends.

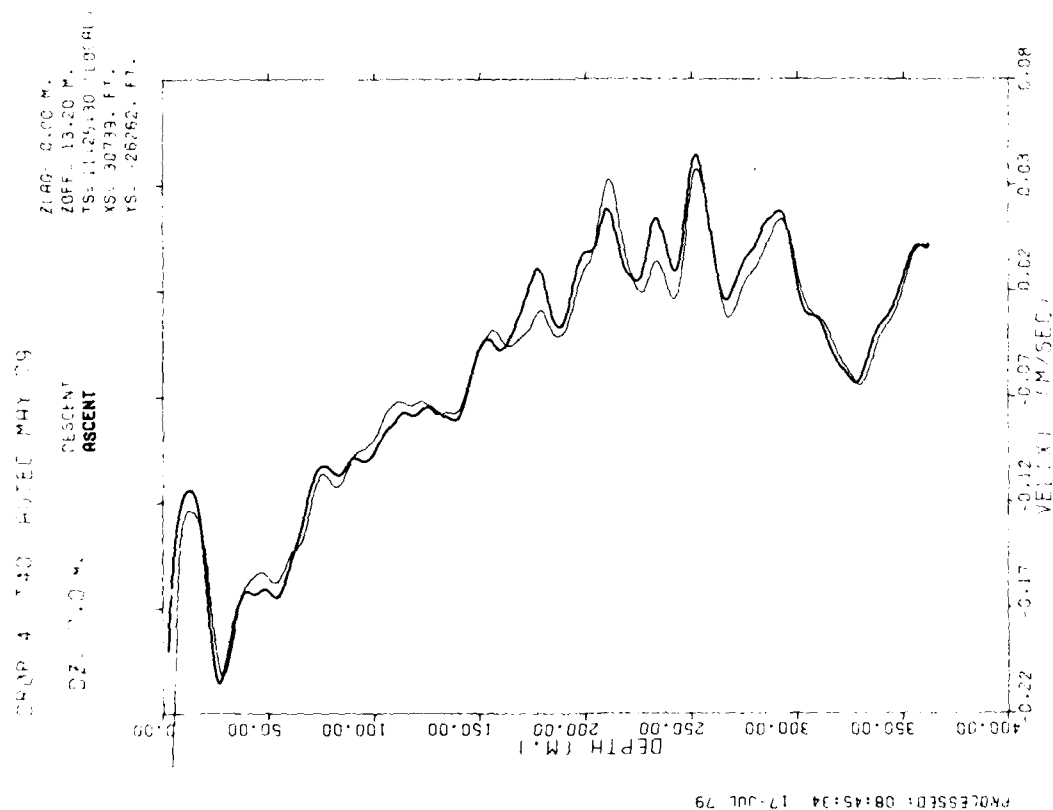
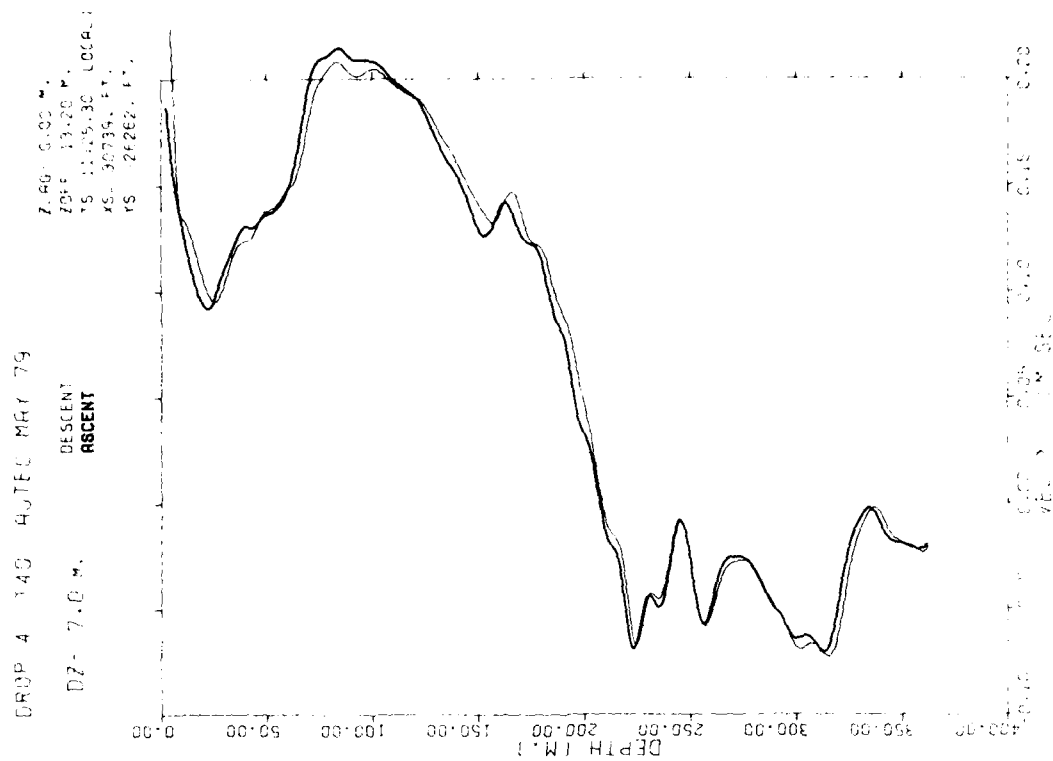


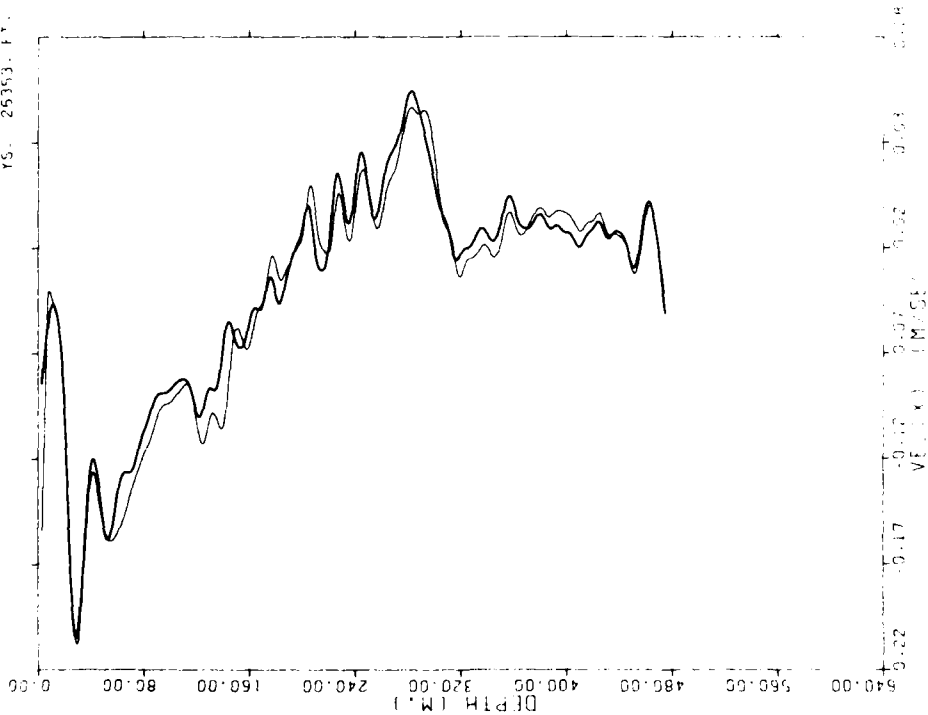
Figure 4d. APL/JHU Drop #4: Profiles of East (VEL(X)) and North (VEL(Y)) velocity components as computed and plotted by D. Wenstrand. Thicker line is as profiler ascends.

DROP 5 140 JUL 20 MAY 79

02 - 7.0 M.

DESCENT
ASCENT

ZLAD: 0.00 M.
ZOFF: 12.90 M.
YS: 13:21:30 (LOCAL)
XS: 30415. FT.
YS: 26353. FT.



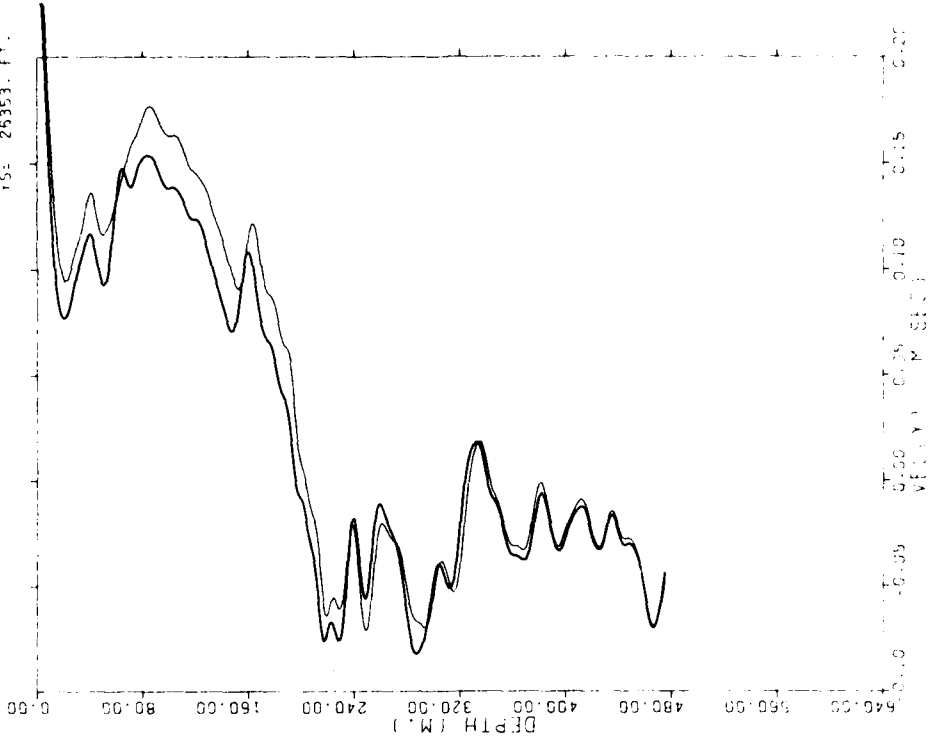
PROF554D: 11:16:39 24-JUL-79

DROP 5 140 JUL 20 MAY 79

02 - 7.0 M.

DESCENT
ASCENT

ZLAD: 0.00 M.
ZOFF: 12.90 M.
YS: 13:21:30 (LOCAL)
XS: 30415. FT.
YS: 26353. FT.



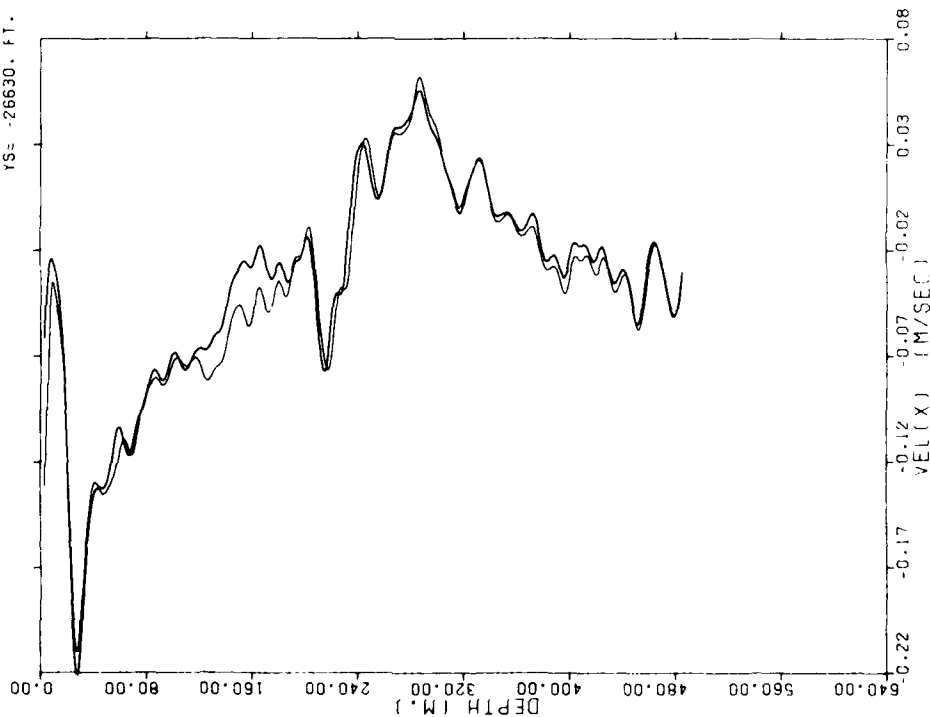
PROF554D: 11:16:39 24-JUL-79

Figure 4e. APL/JHU Drop '5: Profiles of East (VEL(X)) and North (VEL(Y)) velocity components as computed and plotted by D. Wenstrand. Thicker line is as profiler ascends.

DROP 6 T40 AUTC MAY 79

ZLRO= 0.00 M.
ZOFF= 13.20 M.
TS= 15: 9:20 (LOCAL)
XS= 30787. FT.
YS= -26630. FT.

DZ= 7.0 M.
DESCENT
ASCENT

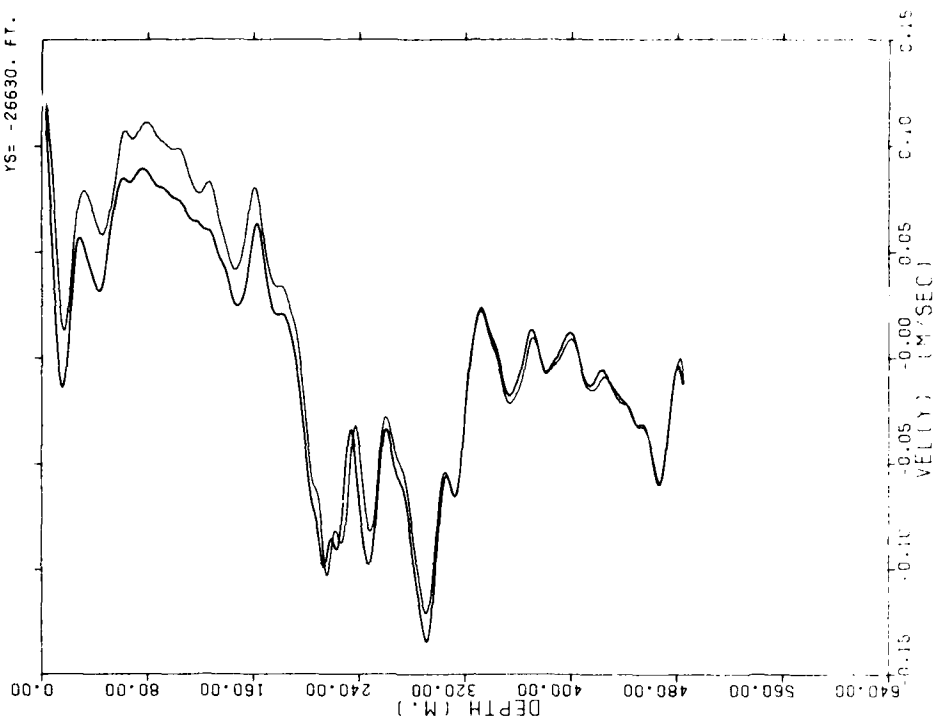


PROCESSED: 08:54:07 31-JUL-79

DROP 6 T40 AUTC MAY 79

ZLRO= 0.00 M.
ZOFF= 13.20 M.
TS= 15: 9:20 (LOCAL)
XS= 30787. FT.
YS= -26630. FT.

DZ= 7.0 M.
DESCENT
ASCENT



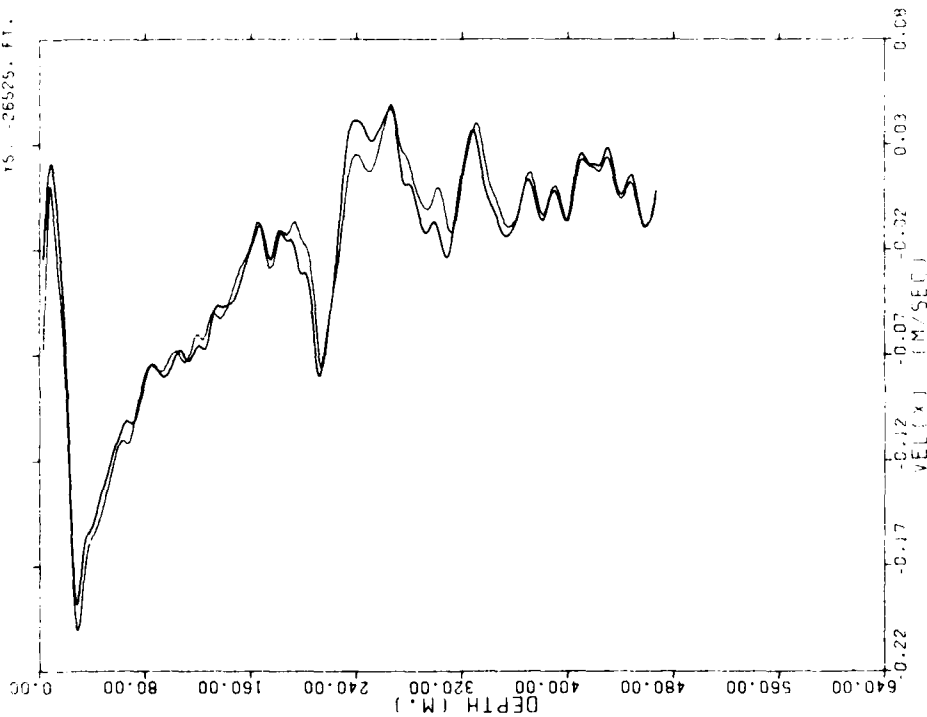
PROCESSED: 08:54:07 31-JUL-79

Figure 4f. APL/JHU Drop #6: Profiles of East (VEL(X)) and North (VEL(Y)) velocity components as computed and plotted by D. Wenstrand. Thicker line is as profiler ascends.

DROP 7 140 RUTEC MAY 79

DZ= 7.0 M.
DESCENT
ASCENT

ZLAG= 0.00 M.
ZOFF= 13.10 M.
TS= 16:52:50 (LOCAL)
XS= 30962. FT.
YS= -26525. FT.



DROP 7 140 RUTEC MAY 79

DZ= 7.0 M.
DESCENT
ASCENT

ZLAG= 0.00 M.
ZOFF= 13.10 M.
TS= 16:52:50 (LOCAL)
XS= 30962. FT.
YS= -26525. FT.

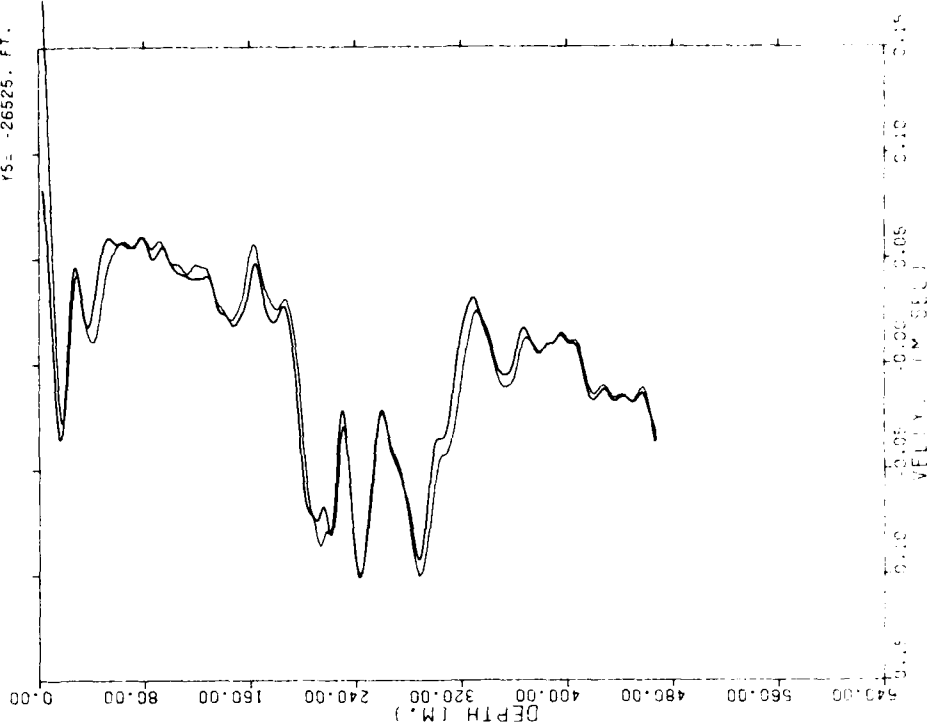


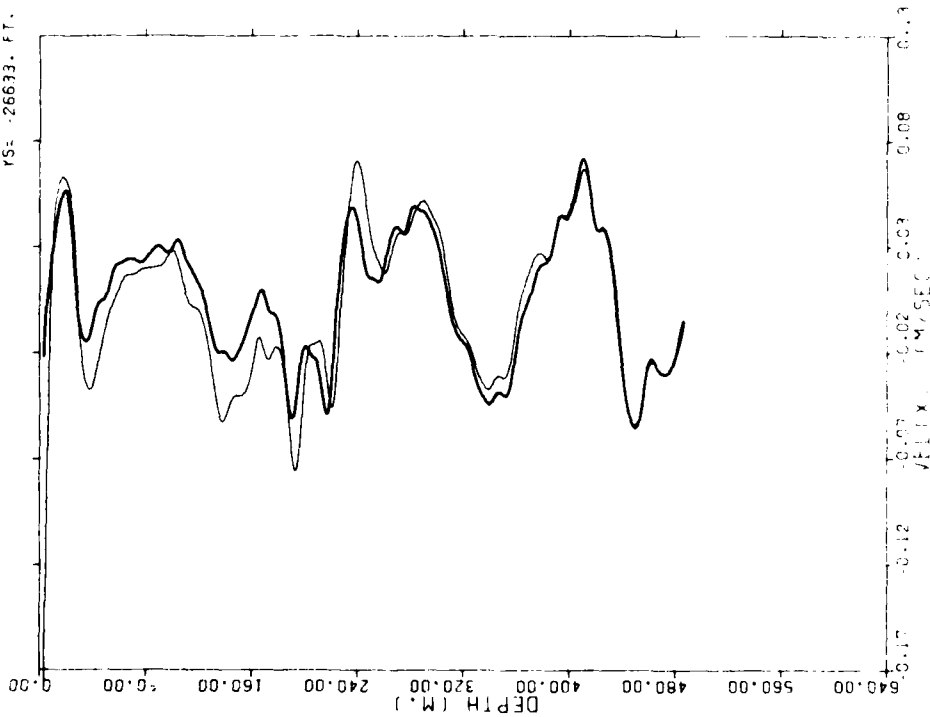
Figure 4g. APL/JHU Drop #7: Profiles of East (VEL(X)) and North (VEL(Y)) velocity components as computed and plotted by D. Wenstrand. Thicker line is as profiler ascends.

DROP 8 T10 AUTEC MAY 79 (OLD PROF.)

ZLAG= 0.00 M.
ZOFF= 12.90 M.
TS= 16:20:18 (LOCAL)
XS= 30303. FT.
YS= -26633. FT.

DESCENT
ASCENT

DZ= 7.0 M.



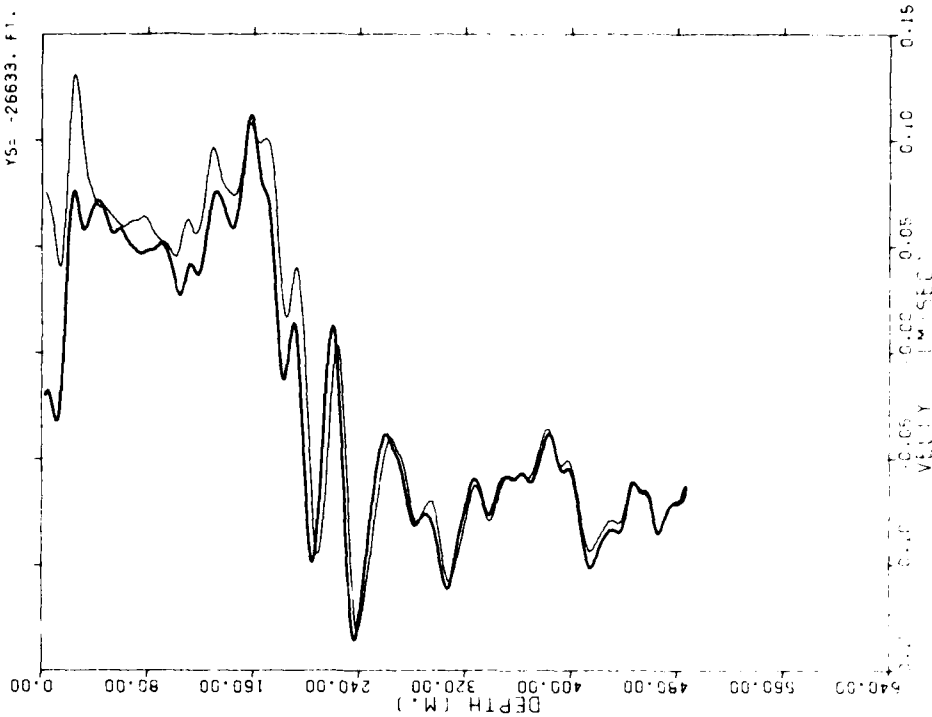
PROCESSED: 09:28:13 06-AUG-79

DROP 8 T10 AUTEC MAY 79 (OLD PROF.)

ZLAG= 0.00 M.
ZOFF= 12.90 M.
TS= 16:20:18 (LOCAL)
XS= 30303. FT.
YS= -26633. FT.

DESCENT
ASCENT

DZ= 7.0 M.



PROCESSED: 09:29:13 06-AUG-79

Figure 4h. APL/JHU Drop #8: Profiles of East (VEL(X)) and North (VEL(Y)) velocity components as computed and plotted by D. Wenstrand. Thicker line is as profiler ascends.

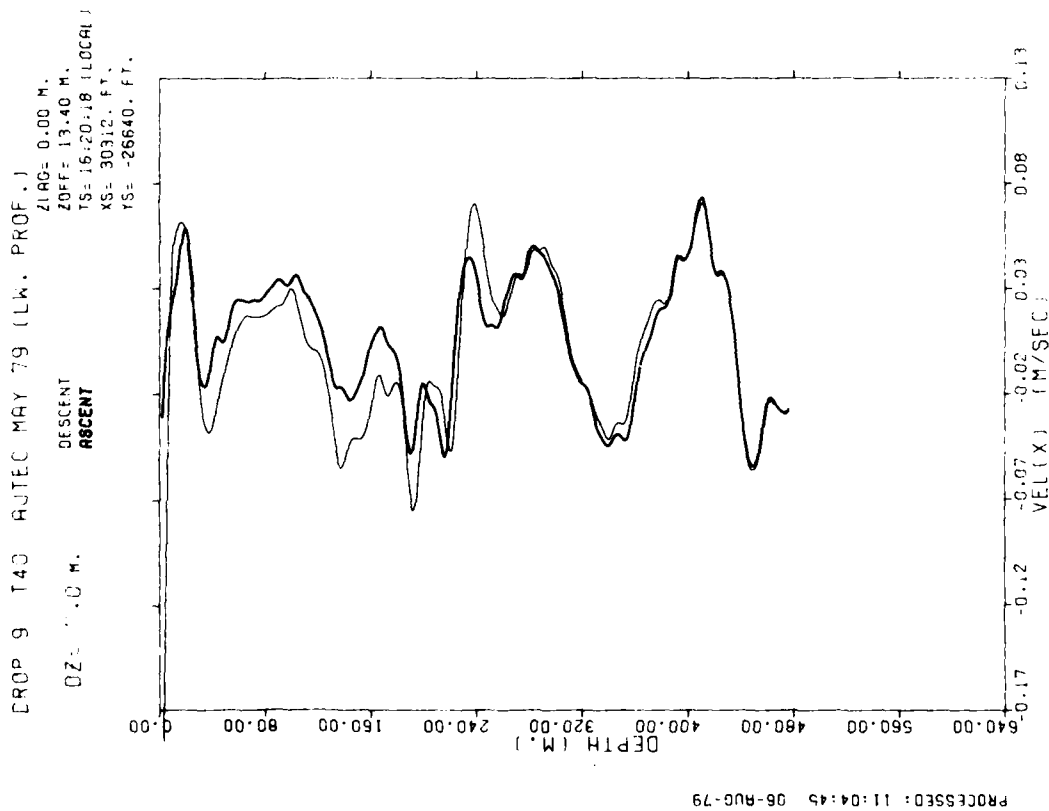
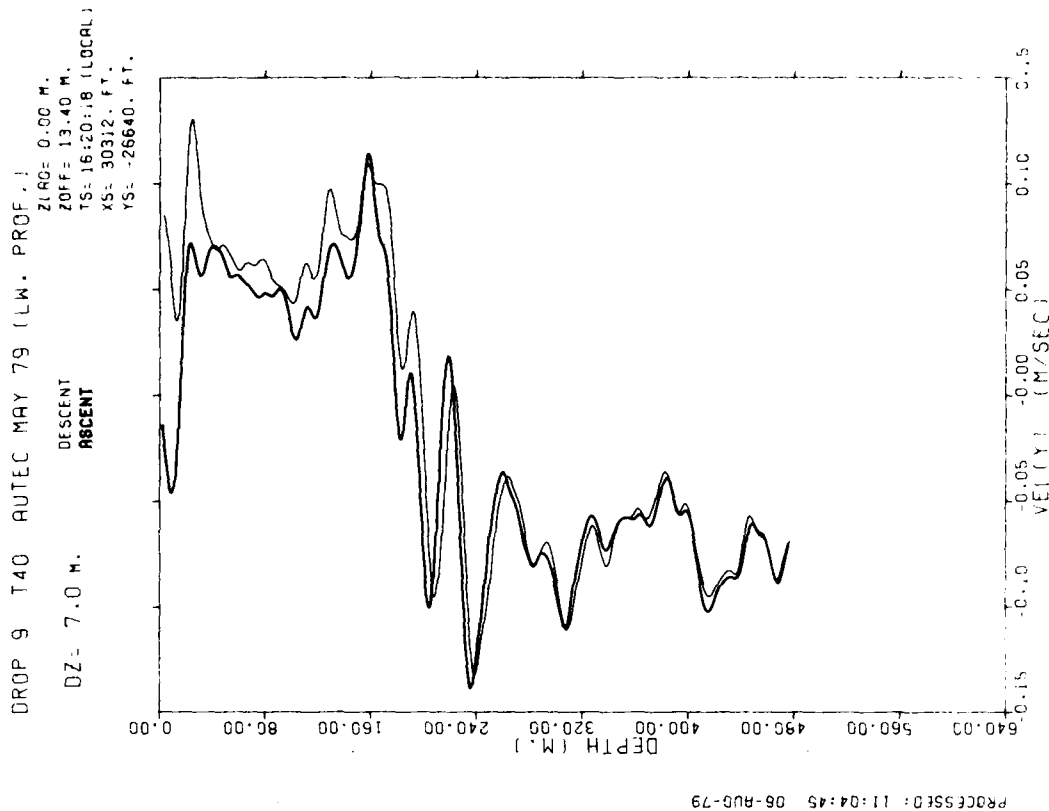
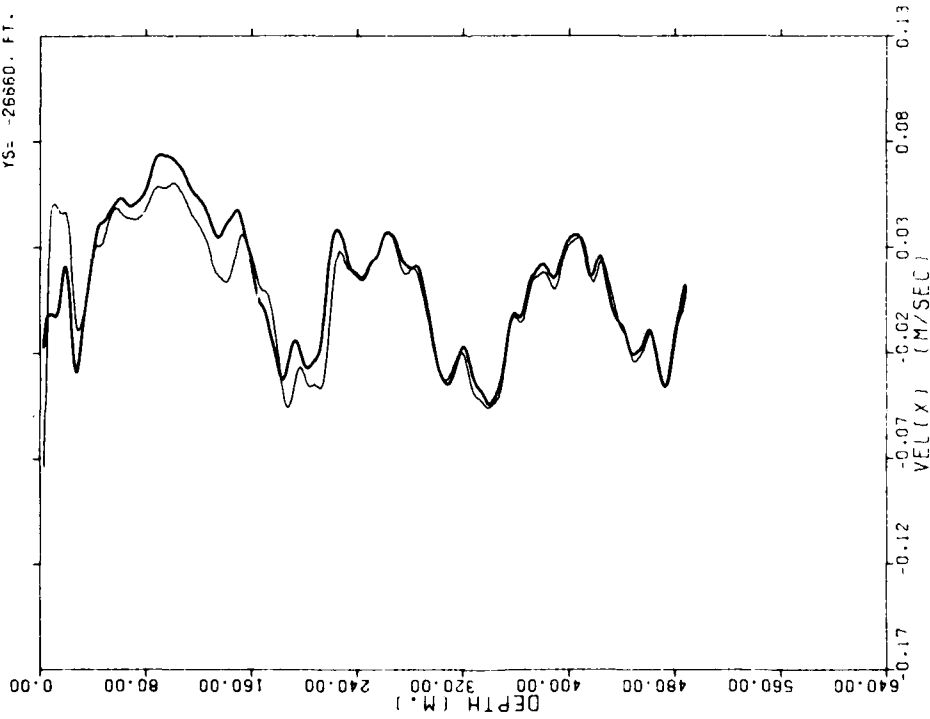


Figure 4i. APL/JHU Drop #9: Profiles of East (VEL(X)) and North (VEL(Y)) velocity components as computed and plotted by D. Wenstrand. Thicker line is as profiler ascends.

DROP 10 T10 AUTEC MAY 79 (OLD PROF.)
 ZLAG= 0.00 M.
 ZOFF= 13.60 M.
 TS= 18:14:48 (LOCAL)
 XS= 30932. FT.
 YS= -26660. FT.

DESCENT
 ASCENT

DZ= 7.0 M.

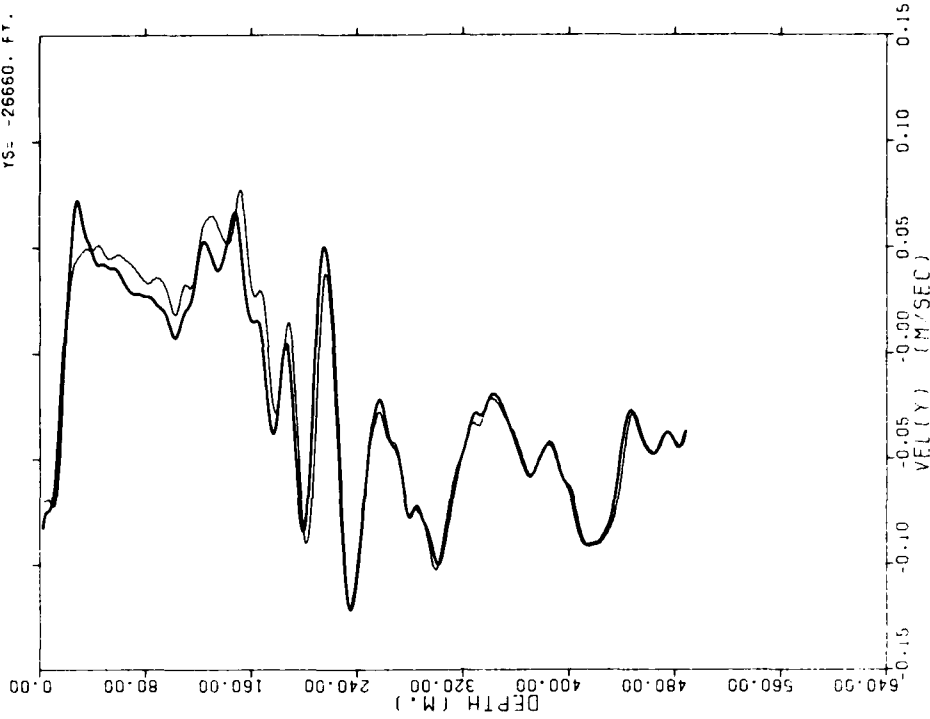


PROCESSED: 13:09:39 06-AUG-79

DROP 10 T10 AUTEC MAY 79 (OLD PROF.)
 ZLAG= 0.00 M.
 ZOFF= 13.60 M.
 TS= 18:14:48 (LOCAL)
 XS= 30932. FT.
 YS= -26660. FT.

DESCENT
 ASCENT

DZ= 7.0 M.



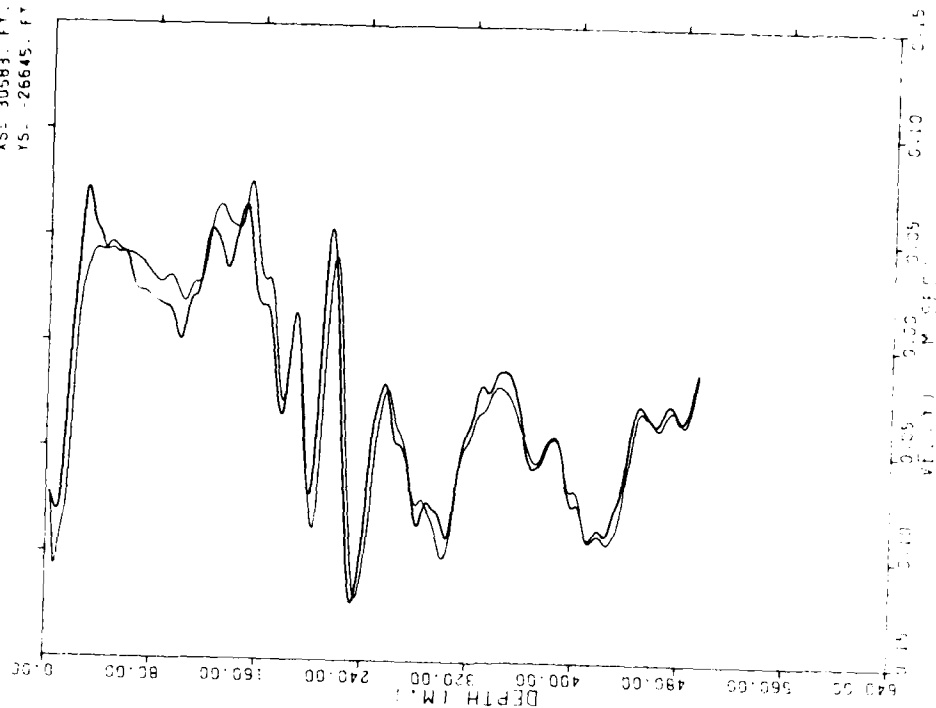
PROCESSED: 13:09:39 06-AUG-79

Figure 4j. APL/JHU Drop #10: Profiles of East (VEL(X)) and North (VEL(Y)) velocity components as computed and plotted by D. Wenstrand. Thicker line is as profiler ascends.

DROP 11 150 AUTEC MAY 79 (LW. PROF.)
 ZRG: 0.00 M.
 ZOFF: 13.80 M.
 TS: 19:20:21 (LOCAL)
 XS: 30583. FT.
 YS: -26645. FT.

DESCENT
 ASCENT

DZ: 7.0 M.

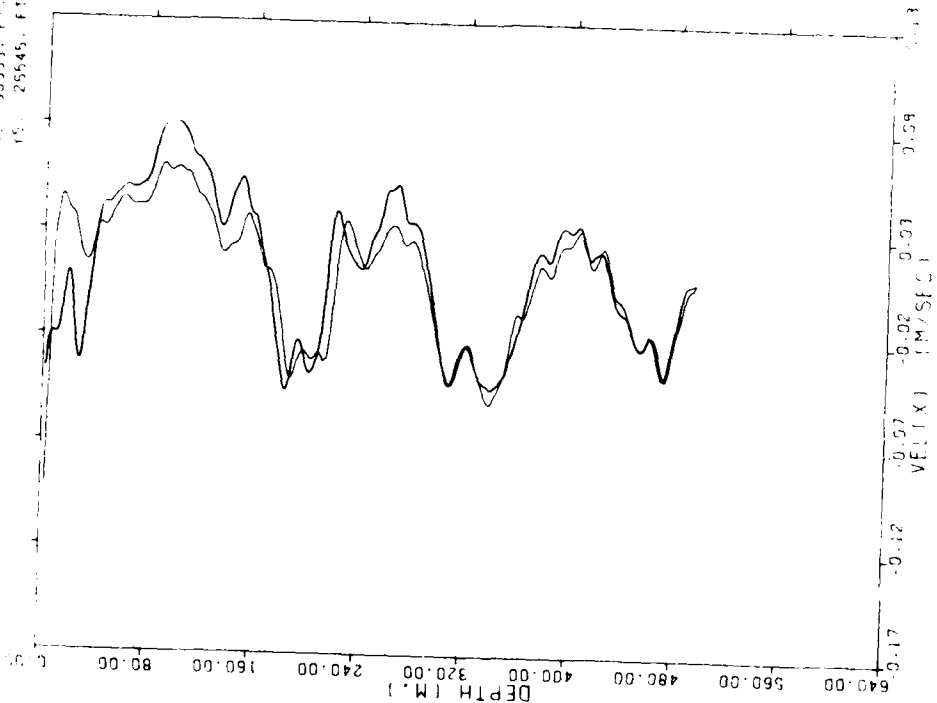


PROCESSED: 09 02:25 08-AUG-79

DROP 11 150 AUTEC MAY 79 (LW. PROF.)
 ZRG: 0.00 M.
 ZOFF: 13.80 M.
 TS: 19:20:21 (LOCAL)
 XS: 30583. FT.
 YS: -26645. FT.

DESCENT
 ASCENT

DZ: 7.0 M.



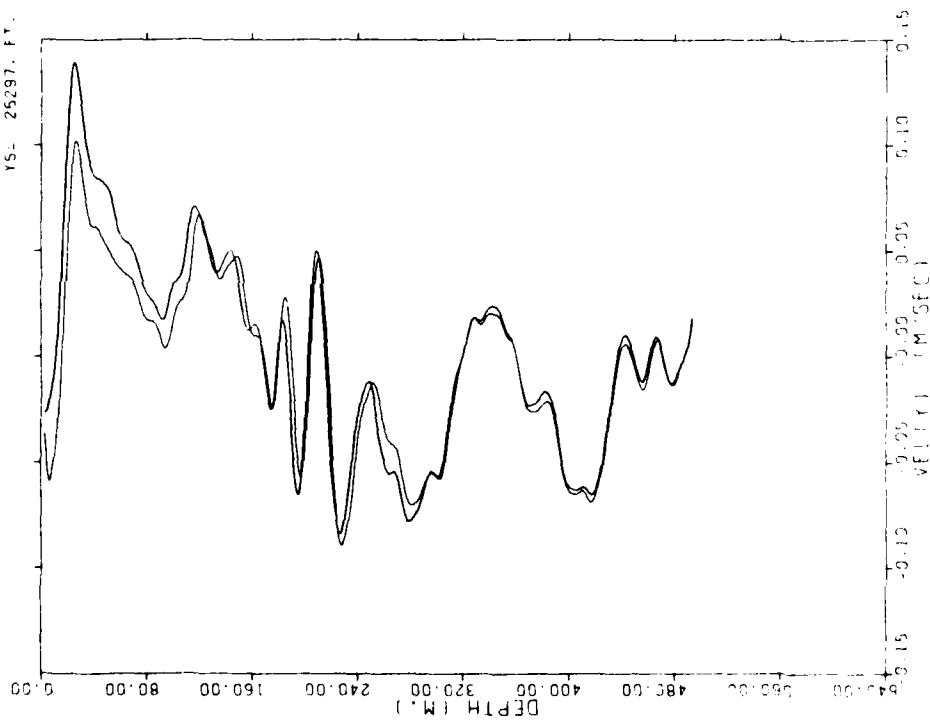
PROCESSED: 09 02:25 08-AUG-79

Figure 4k. APL/JHU Drop #11: Profiles of East (VEL(X)) and North (VEL(Y)) velocity components as computed and plotted by D. Wenstrand. Thicker line is as profiler ascends.

DROP 12 110 AUTEC MAY 79 (OLD PROF.)

DZ = 7.0 M.
ZLAGE = 0.00 M.
ZOFF = 14.20 M.
TS = 20:10:28 (LOCAL)
XS = 31271. FT.
YS = 25297. FT.

DESCENT
ASCENT

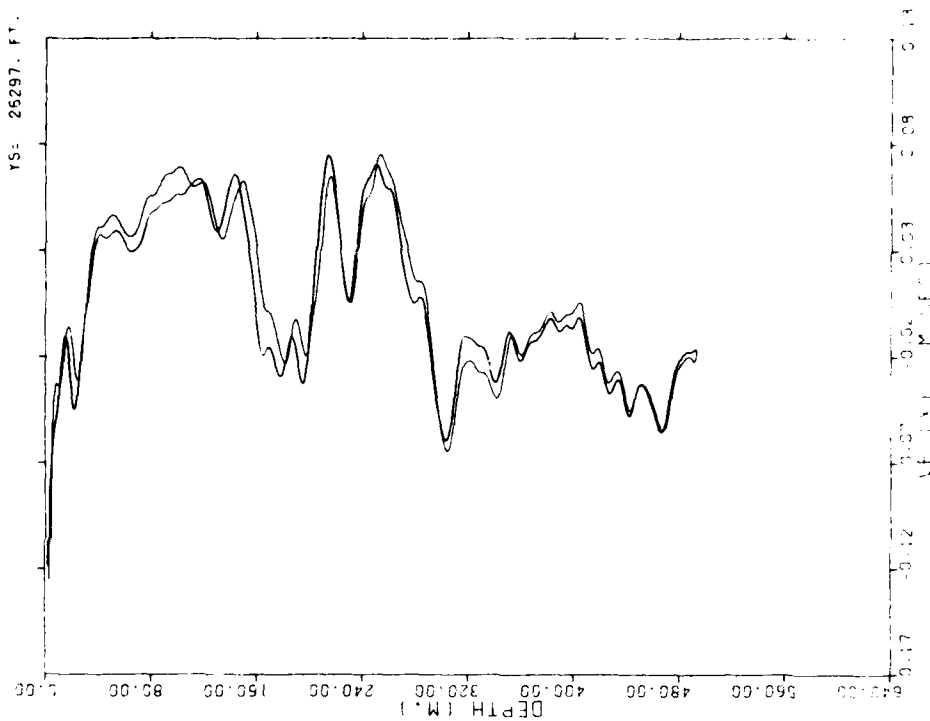


PROF155450: 10:31:04 08 AUG 79

DROP 12 110 AUTEC MAY 79 (OLD PROF.)

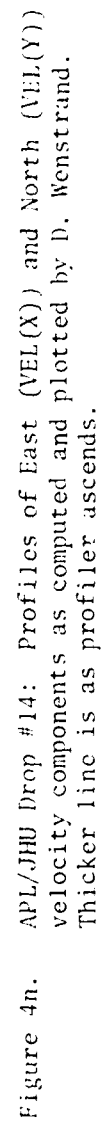
DZ = 7.0 M.
ZLAGE = 0.00 M.
ZOFF = 14.20 M.
TS = 20:10:28 (LOCAL)
XS = 31271. FT.
YS = 25297. FT.

DESCENT
ASCENT



PROF155450: 10:31:04 09 AUG 79

Figure 41. APL/JHU Drop #12: Profiles of East (VEL(X)) and North (VEL(Y)) velocity components as computed and plotted by D. Wenstrand. Thicker line is as profiler ascends.



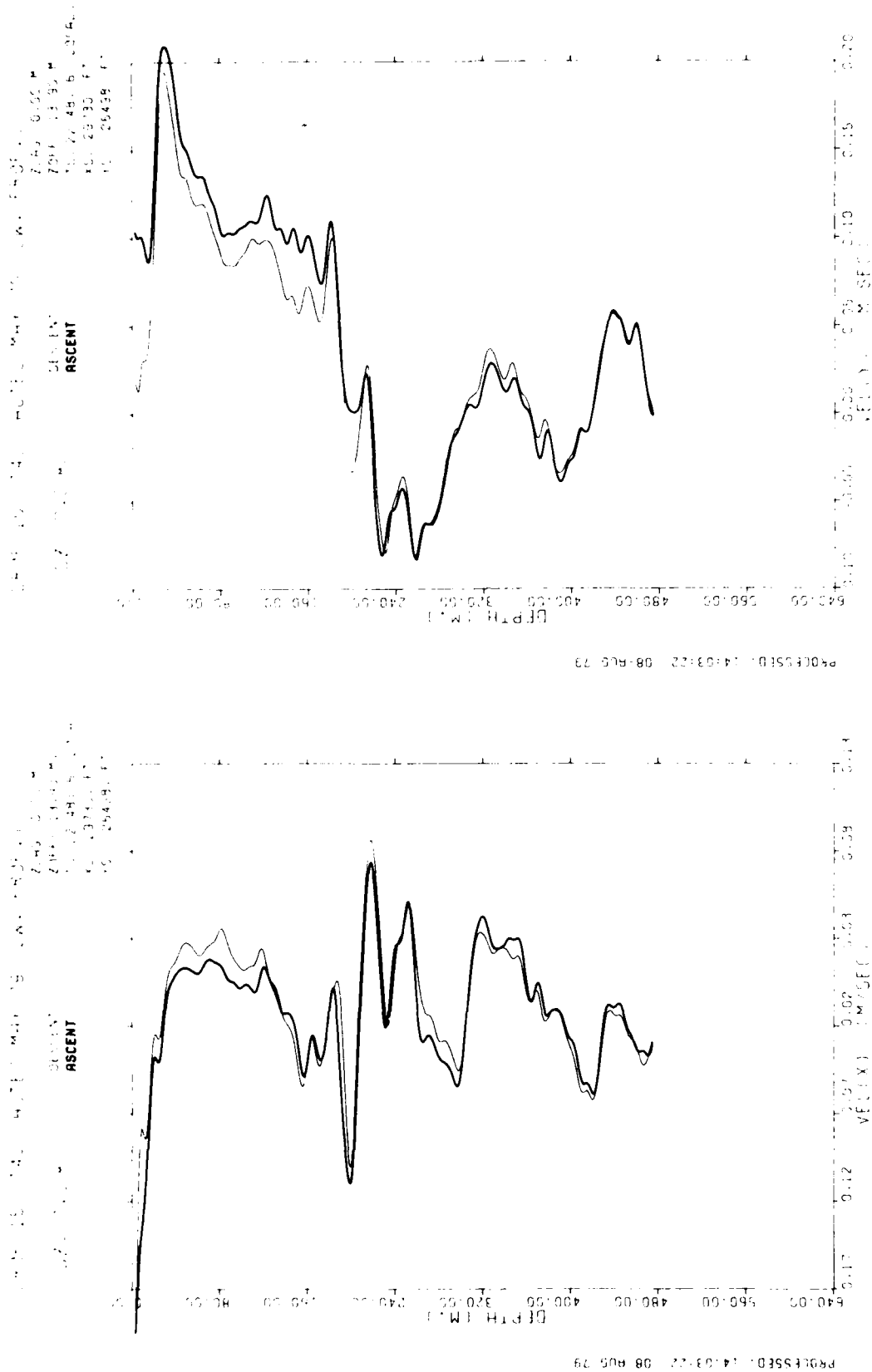


Figure 40. APL/JHU Drop #15: Profiles of East (VEL(X)) and North (VEL(Y)) velocity components as computed and plotted by D. Wenstrand. Thicker line is as profiler ascends.

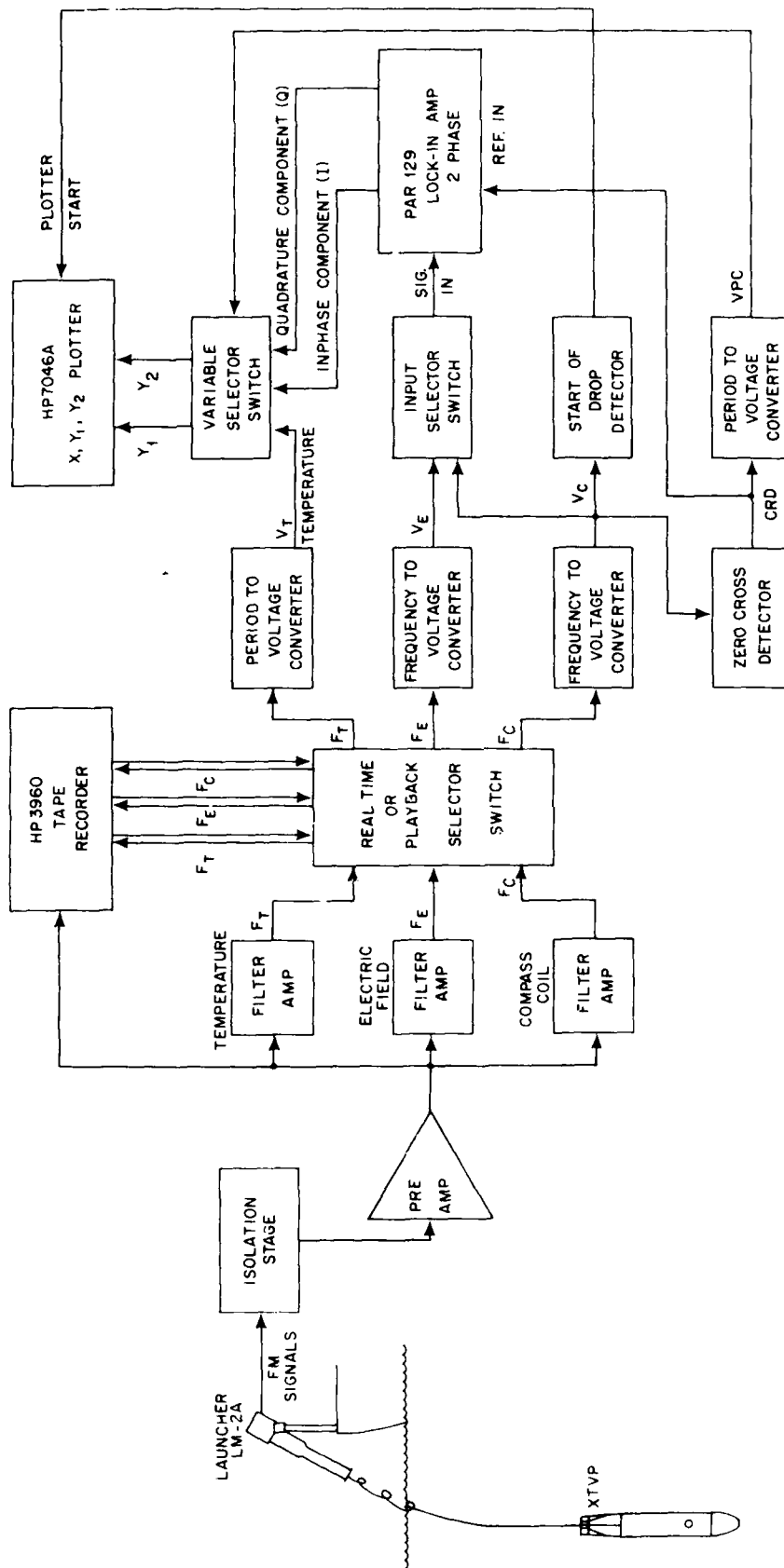


Figure 5. AUTEC Shipboard and Playback Processing System.

V. RESULTS AND DISCUSSION

The purpose of this section is to evaluate the performance of the XTVP relative to the APL/JHU profiler. The intercomparison will be performed in stages of increasingly finer examination. The first stage is a visual comparison of nearly simultaneous profiles. These data are presented in Figures 6a through 6g. There is a high degree of similarity; even small-scale features are in common.

The second stage of analysis is to quantify XTVP performance relative to all appropriate acoustic profiles, regardless of the 10-minute simultaneity and 100 m horizontal separation restriction. The procedure is to compute the rms difference between profiles as a function of vertical lag. This statistic is related to a structure function

$$R_{ij}(U, \Delta z) = \overline{[U_i(z) - U_j(z + \Delta z)]^2}$$

where U_i and U_j are the east components of velocity of the i th and j th profiles, Δz is the depth lag or offset, and the overbar is an average over depth (typically -100 to -500 m). Similar expressions are used for the north component (V) and for U and V taken together. In the latter case,

$$R(U, V, \Delta z) = \overline{[U_i(z) - U_j(z + \Delta z)]^2 + [V_i(z) - V_j(z + \Delta z)]^2}.$$

These statistics are computed for a range of Δz values, but the value of Δz for which R is the minimum is of special importance. The minimum $R^{1/2}$ is taken to be the rms deviation between profile pairs regardless of the depth offset. Because a preliminary fall rate versus time relation was used for the XTVP profiles, there are systematic depth offsets between XTVP and APL/JHU profiles.

The minimum rms differences are presented in a series of arrays for all appropriate profiles in Tables 4a through 4g.

For the whole data set, the rms differences over the span of simultaneous data for APL/JHU (down), APL/JHU (up), and XTVP are:

1. APLD vs. APLU: 7 realizations

$$\sigma_{\Delta u} = 1.0 \text{ cm/s}$$

$$\sigma_{\Delta v} = 0.9 \text{ cm/s}$$

2. XTVP vs. XTVP: 27 realizations

$$\sigma_{\Delta u} = 1.0 \text{ cm/s}$$

$$\sigma_{\Delta v} = 1.3 \text{ cm/s}$$

3. APLD or APLU vs. XTVP: 44 realizations (22 vs. D and 22 vs. U profiles)

$$\sigma_{\Delta u} = 1.1 \text{ cm/s}$$

$$\sigma_{\Delta v} = 1.5 \text{ cm/s.}$$

When comparing data from two profiles produced by the same technique, it seems reasonable to divide the errors equally between the two profiles. Consider two variables, U_1 and U_2 , each having a random noise contribution ϵ . The mean difference, $\overline{U_1 - U_2}$, is forced to be zero (the vertical mean is meaningless in the XTVP method), and the mean squared difference is

$$\sigma^2 = \overline{(U_1 + \epsilon_1 - U_2 - \epsilon_2)^2} = \overline{\epsilon_1^2} + \overline{\epsilon_2^2} - 2 \overline{\epsilon_1 \epsilon_2},$$

where the overbar represents the vertical mean.

If the errors are uncorrelated between profiles, then

$$\sigma_{\Delta u}^2 = \overline{\epsilon_1^2} + \overline{\epsilon_2^2} = 2\epsilon^2$$

if errors are equally distributed between profiles.

Thus, for ensemble-averaged σ values of 1.0 and 1.3 cm/s for east and north XTVP differences, the appropriate error estimate for a single profile would be 1.0 and 1.3 cm/s divided by $\sqrt{2}$, or 0.7 and 0.9 cm/s respectively. Similarly, the APL/JHU random errors would be 0.7 and 0.6 cm/s.

Another test of the APL/JHU data is to compare the profiles obtained with two profilers operated simultaneously. There are three examples of these which we examined: APL/JHU 8 and 9, 10 and 11, and 12 and 13. A fourth example was 14 and 15, but there clearly are problems with these data, especially 14, because the tracking computer was switching hydrophone sets in an attempt to maximize signal strength. The rms differences are shown in Table 5. The average for nearly simultaneous profiles is 0.9 cm/s for east and for north components. Sharing the variance equally yields an rms value of 0.6 cm/s.

Wenstrand (personal communication) has analyzed the difference between drops 8 and 9 and found 0.3 cm/s for east and 0.2 cm/s for north over 100 to 450 m. We find differences of 0.6 to 0.8 over a slightly longer interval. The higher rms differences probably result from errors made in the tracing (digitization) of graphs provided by APL/JHU.

Recent analyses by Sanford and D'Asaro (unpublished) have shown that an error of about 1.0 cm/s rms exists in the north velocity component due to tilts of the XTVP probes. Thus, even if we ignore any errors contributed by the APL/JHU technique and assume all differences are due to XTVP errors, the 1.1 cm/s rms difference in east remains 1.1 cm/s and the 1.5 cm/s rms difference in north becomes

$$\sqrt{(1.5)^2 - (1.0)^2} = 1.1 \text{ cm/s} .$$

In summary, the AUTEC profiles support a random error level of about ± 1 cm/s for the XTVP compared with the APL/JHU profiler.

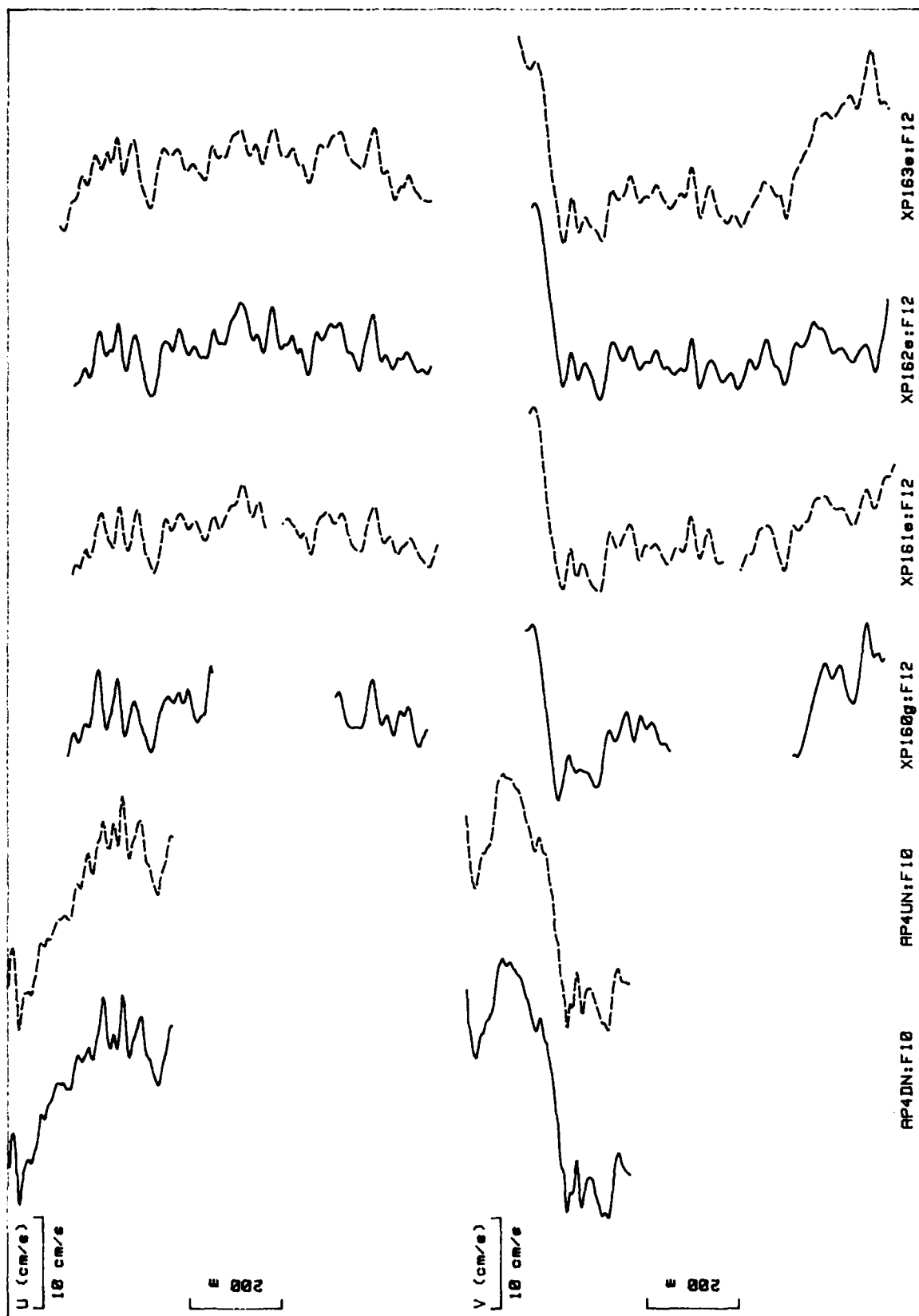


Figure 6a. Comparison of nearly simultaneous velocity profiles.

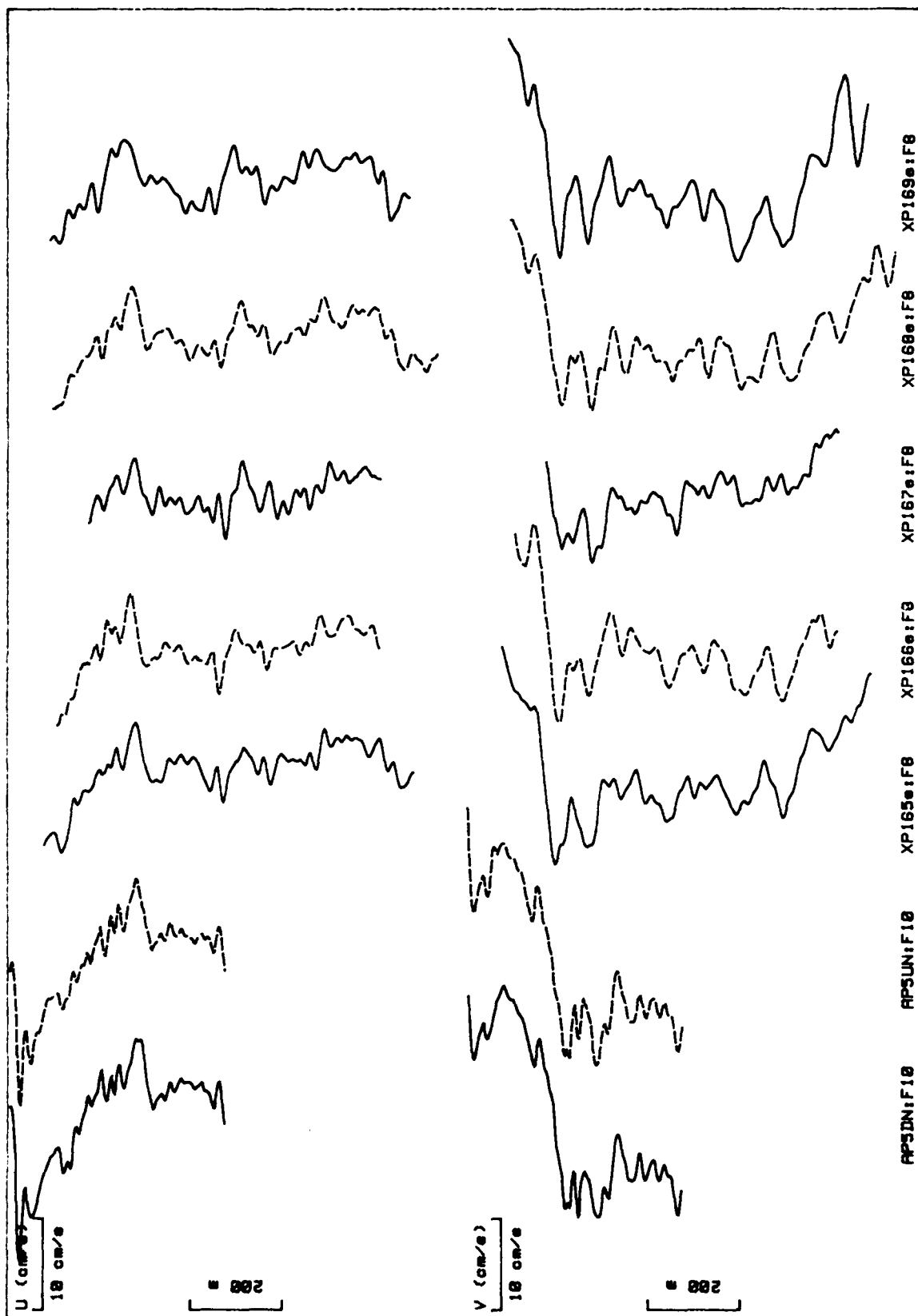


Figure 6b. Comparison of nearly simultaneous velocity profiles.

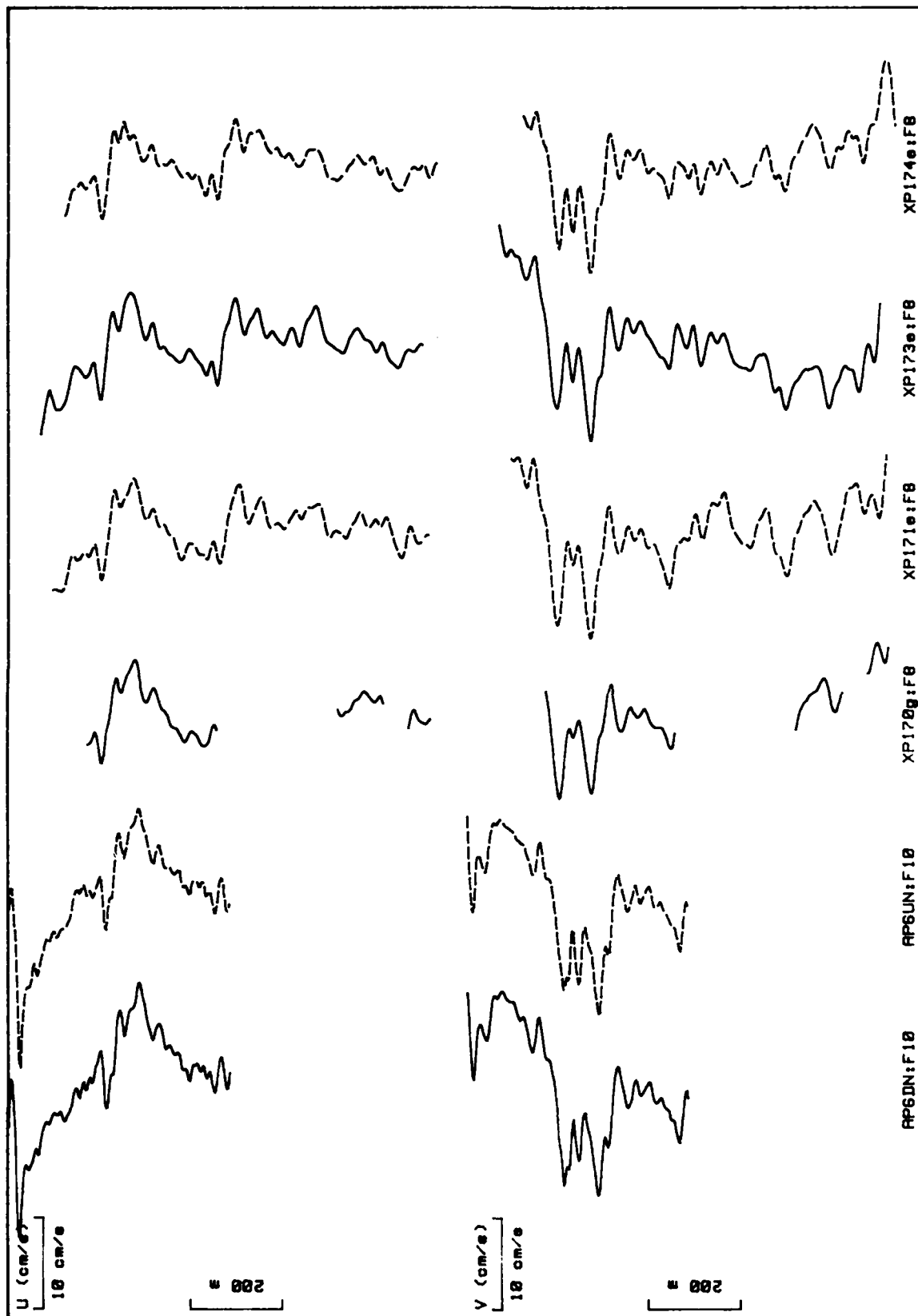


Figure 6c. Comparison of nearly simultaneous velocity profiles.

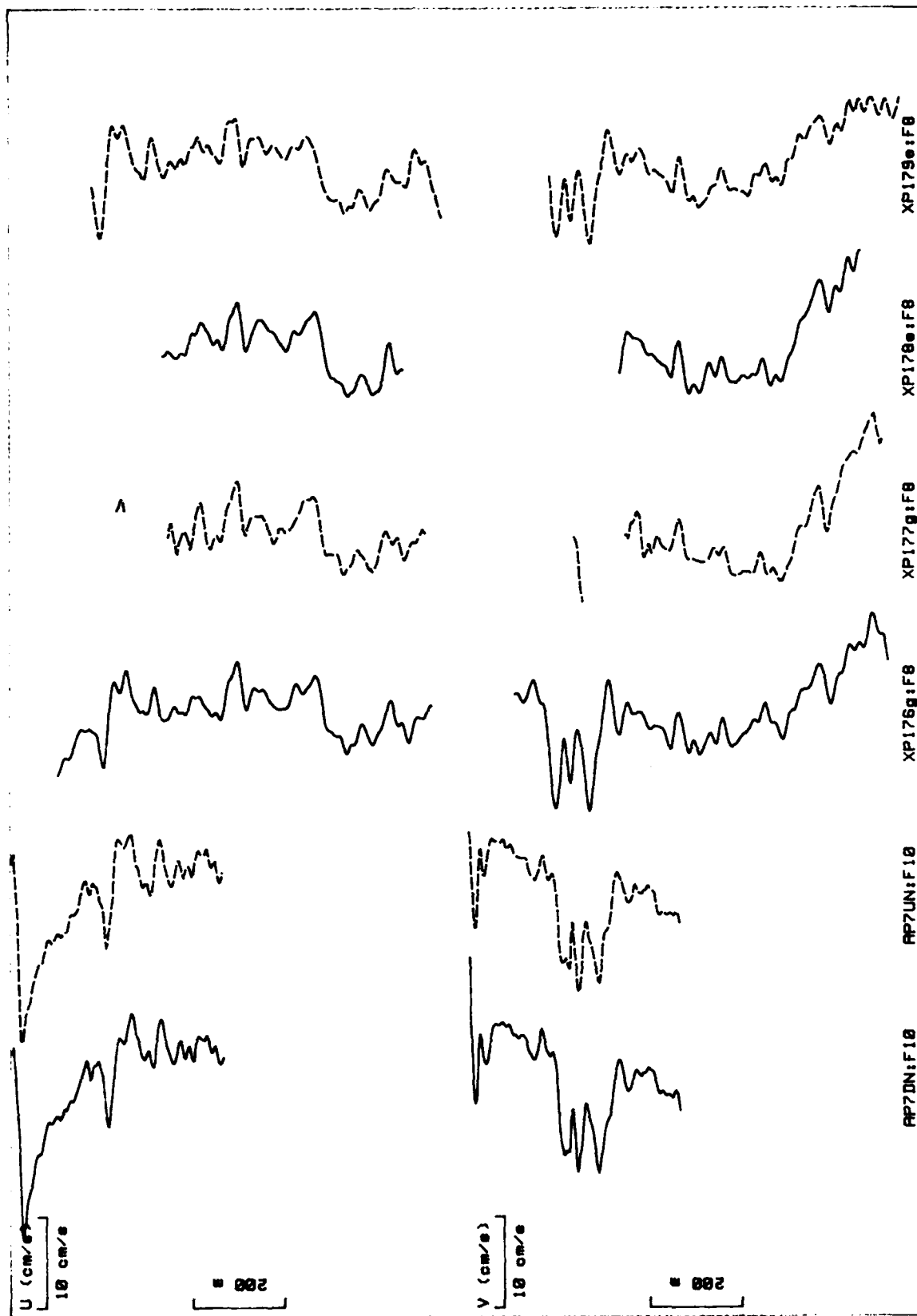


Figure 6d. Comparison of nearly simultaneous velocity profiles.

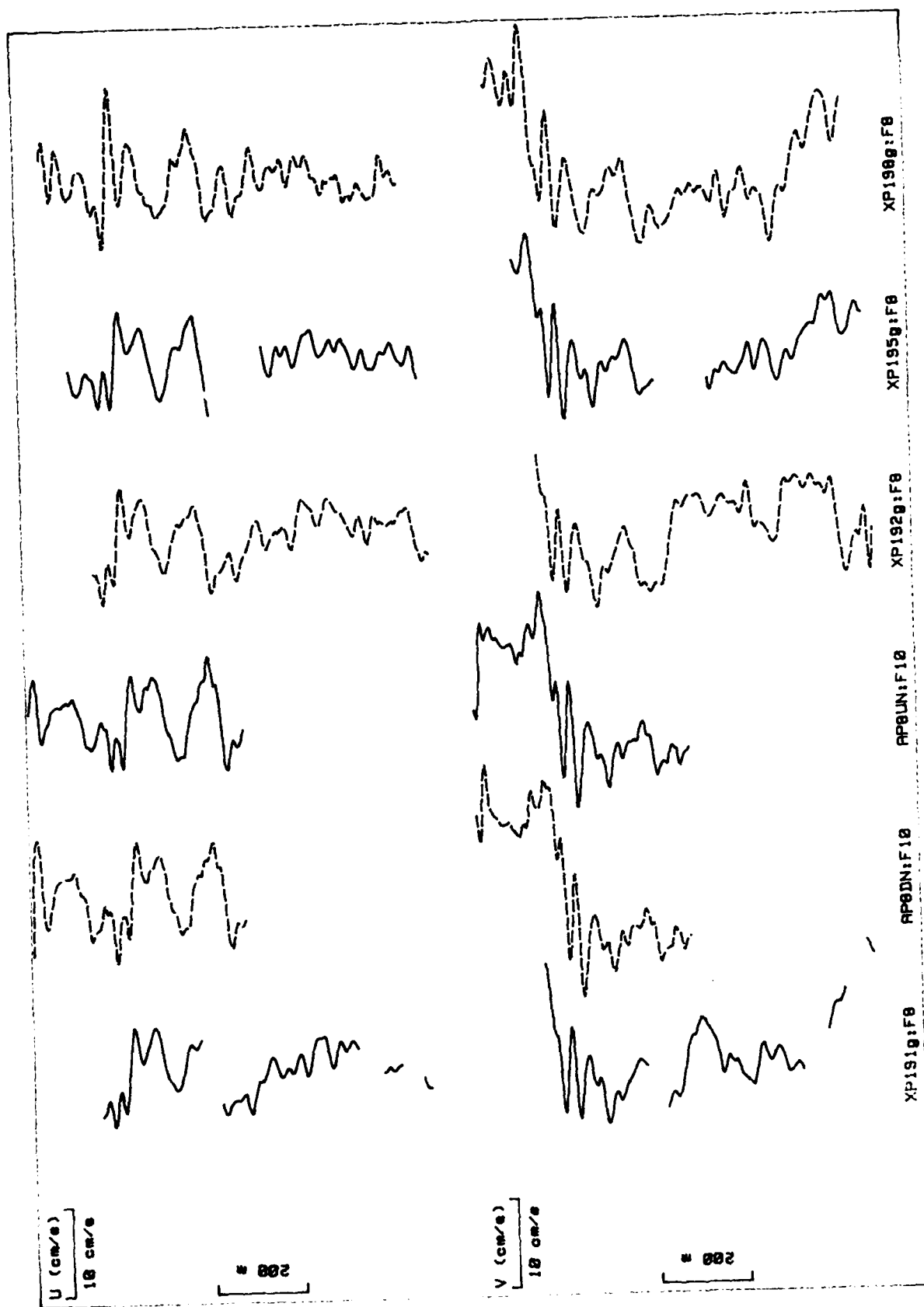


Figure 6e. Comparison of nearly simultaneous velocity profiles.

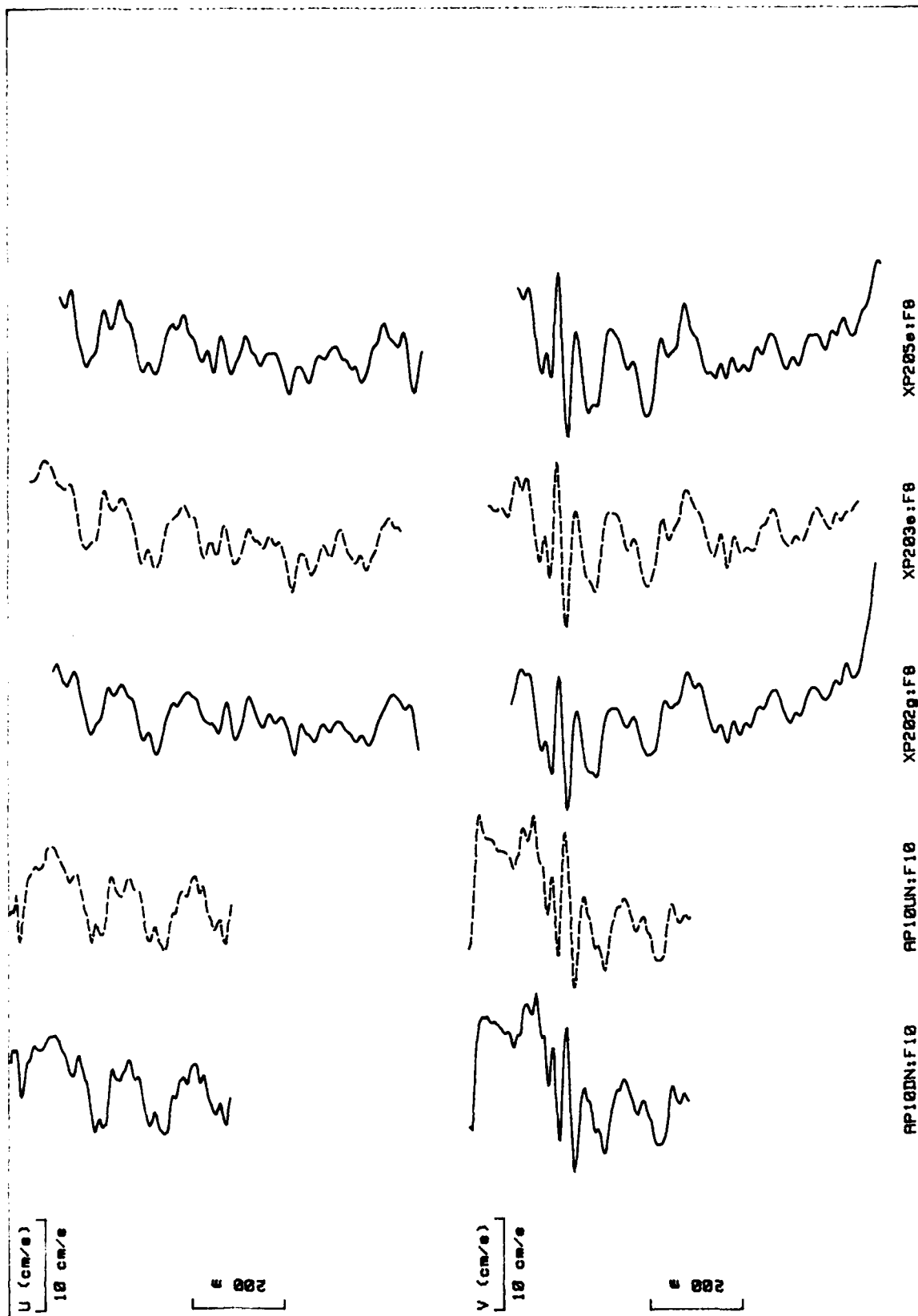


Figure 6f. Comparison of nearly simultaneous velocity profiles.

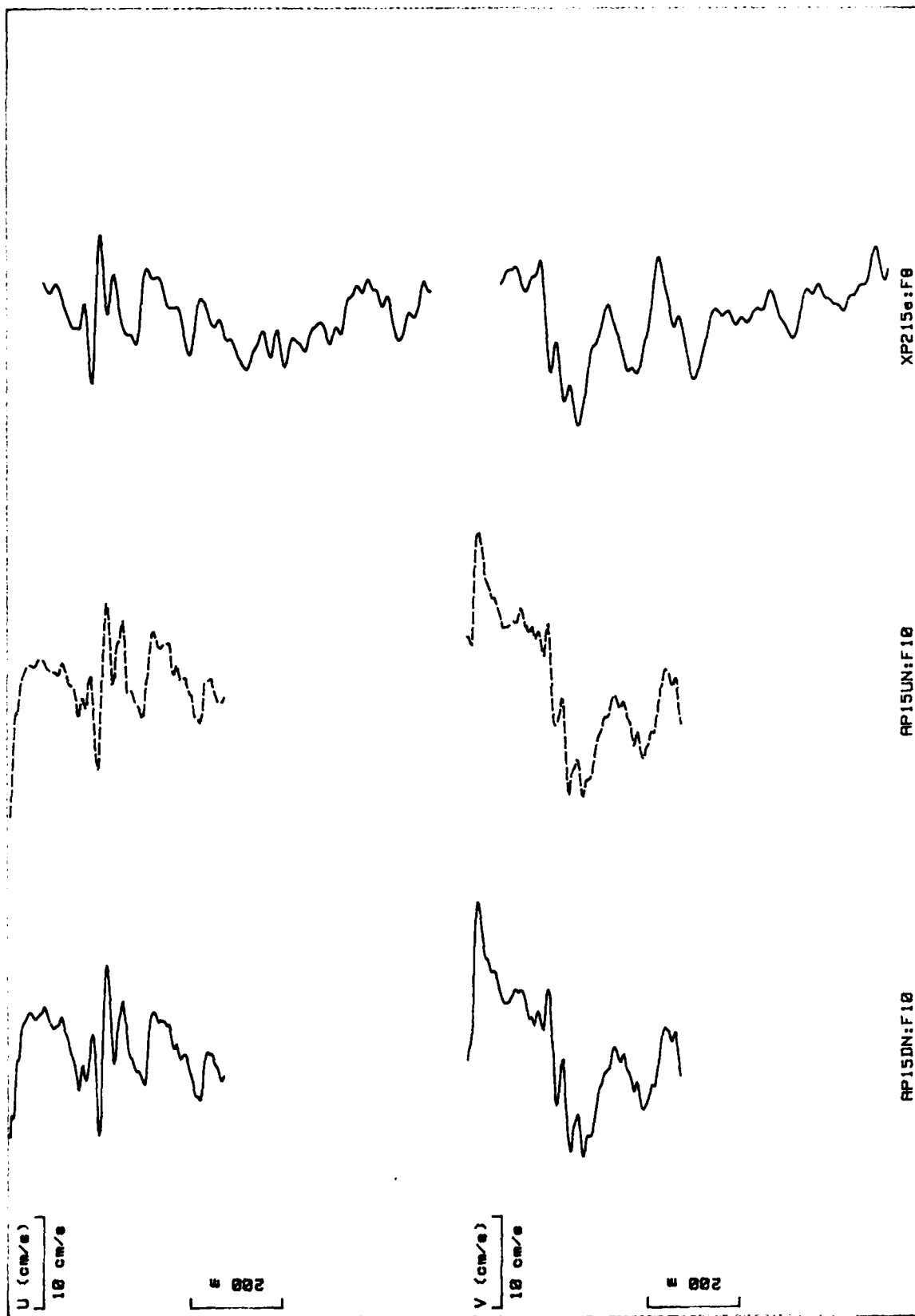


Figure 6g. Comparison of nearly simultaneous velocity profiles.

Table 4a. Minimum values of the square root of the cross-structure function for east, north, and east-and-north velocity components computed between -100 and -340 m depth. The entries are for east, north, and combined in that order reading downward in each column. The units are centimeters/second. The depth offset at minimum in meters is shown in parentheses, where a positive value means column profile must be shifted down to agree with row profile.

	AP4U	XP160G	XP161E	XP162E	XP163E
AP4D	1.5(0) 0.7(2) 1.2(0)	0.8(11) 1.4(24) 1.8(18)	0.9(7) 1.1(20) 1.8(13)	0.8(11) 0.7(13) 0.9(13)	1.3(13) 1.2(15) 1.2(15)
AP4U		1.5(11) 1.1(22) 1.8(18)	1.1(7) 1.4(18) 1.6(13)	0.9(11) 0.7(13) 0.8(11)	0.8(13) 0.8(13) 0.8(13)
XP160G			0.9(-4) 0.9(-4) 0.9(-4)	0.9(0) 1.2(-9) 1.4(-4)	1.4(2) 0.9(-9) 1.6(-4)
XP161E				0.6(4) 0.7(-4) 1.2(-2)	0.9(7) 0.5(-4) 1.4(0)
XP162E					0.7(4) 0.7(0) 0.8(2)

Table 4b. Minimum values of the square root of the cross-structure function for east, north, and east-and-north velocity components computed between -100 and -450 m depth. The entries are for east, north, and combined in that order reading downward in each column. The units are centimeters/second. The depth offset at minimum in meters is shown in parentheses, where a positive value means column profile must be shifted down to agree with row profile.

	AP5U	XP165G	XP166E	XP168E
AP5D	0.8(2)	0.8(7)	1.0(15)	1.2(13)
	1.1(2)	1.8(29)	2.0(20)	1.6(15)
	0.9(2)	2.0(24)	1.6(20)	1.4(13)
AP5U		0.9(2)	0.8(11)	0.7(9)
		1.7(24)	1.7(18)	1.0(11)
		1.9(20)	1.4(15)	0.9(11)
XP165G			1.1(9)	1.2(7)
			1.4(-2)	1.5(-9)
			1.6(0)	1.7(-2)
				0.9(-2)
				1.6(-4)
				1.3(-4)

Table 4c. Minimum values of the square root of the cross-structure function for east, north, and east-and-north velocity components computed between -100 and -500 m depth. The entries are for east, north, and combined in that order reading downward in each column. The units are centimeters/second. The depth offset at minimum in meters is shown in parentheses, where a positive value means column profile must be shifted down to agree with row profile.

	AP6U	XP170G	XP171E	XP173E	XP174E
AP6D	0.8(2)	0.8(11)	0.9(13)	1.0(18)	1.5(15)
	1.0(2)	1.4(15)	1.3(20)	1.2(20)	1.2(18)
	0.8(2)	1.3(13)	1.1(18)	1.1(18)	1.4(18)
AP6U		0.9(9)	0.8(13)	1.0(15)	1.3(15)
		1.9(13)	1.7(18)	1.5(18)	1.1(15)
		1.5(13)	1.4(15)	1.2(15)	1.2(15)
XP170G			0.5(2)	0.8(4)	1.3(4)
			0.9(4)	1.3(4)	1.6(2)
			0.7(4)	1.1(4)	1.4(4)
XP171E				0.7(2)	1.1(2)
				1.0(0)	1.5(-2)
				0.9(0)	1.3(0)
XP173E					1.0(0)
					1.2(0)
					1.1(0)

Table 4d. Minimum values of the square root of the cross-structure function for east, north, and east-and-north velocity components computed between -100 and -470 m depth. The entries are for east, north, and combined in that order reading downward in each column. The units are centimeters/second. The depth offset at minimum in meters is shown in parentheses, where a positive value means column profile must be shifted down to agree with row profile.

	AP7U	XP176G	XP177G	XP178E	XP179E
AP7D	0.7(2)	0.8(11)	1.4(18)	1.3(11)	1.1(15)
	0.7(2)	1.2(20)	1.4(20)	0.6(20)	1.3(18)
	0.7(2)	1.3(18)	1.4(20)	1.0(15)	1.2(15)
AP7U		0.9(9)	1.2(11)	1.0(9)	0.7(11)
		1.2(18)	1.3(20)	0.7(18)	1.2(15)
		1.5(15)	1.4(20)	0.8(13)	1.1(13)
XP176G			1.2(11)	0.8(-7)	1.0(2)
			1.0(7)	0.4(-2)	0.8(-2)
			1.1(7)	0.7(-2)	0.8(-2)
XP177G				1.3(-4)	1.2(0)
				1.1(-7)	0.8(-11)
				1.2(-7)	1.2(-9)
XP178E					0.6(0)
					0.5(-2)
					0.6(-2)

Table 4e. Minimum values of the square root of the cross-structure function for east, north, and east-and-north velocity components computed between -100 and -500 m depth. The entries are for east, north, and combined in that order reading downward in each column. The units are centimeters/second. The depth offset at minimum in meters is shown in parentheses, where a positive value means column profile must be shifted down to agree with row profile.

	AP8U	XP192G	XP195G	XP198G
AP8D	0.9(2) 1.9(2) 1.1(2)	1.5(20) 1.8(20) 1.7(20)	1.4(15) 1.7(18) 1.5(15)	2.1(24) 2.6(26) 2.4(24)
AP8U		2.0(18) 2.1(15) 2.1(18)	1.8(15) 1.1(13) 1.5(13)	1.9(20) 2.0(22) 1.9(22)
XP192G			1.1(-2) 2.8(-2) 2.1(-2)	2.4(4) 3.6(7) 3.1(7)
XP1956				2.2(9) 1.9(9) 2.1(9)

Table 4f. Minimum values of the square root of the cross-structure function for east, north, and east-and-north velocity components computed between -100 and -500 m depth. The entries are for east, north, and combined in that order reading downward in each column. The units are centimeters/second. The depth offset at minimum in meters is shown in parentheses, where a positive value means column profile must be shifted down to agree with row profile.

	AP10U	XP202G	XP203E	XP205E
AP10D	0.6(2)	0.8(11)	1.0(18)	1.0(20)
	1.0(2)	2.6(15)	2.1(20)	2.1(15)
	0.8(2)	2.0(15)	1.7(20)	1.7(18)
AP10U		1.0(9)	.9(15)	1.1(18)
		2.4(15)	1.8(18)	1.8(15)
		1.9(13)	1.4(18)	1.5(15)
XP202G			.8(7)	.8(9)
			1.1(4)	1.5(0)
			1.0(4)	1.4(0)
XP203E				1.0(2)
				1.1(-4)
				1.0(-2)

Table 4g. Minimum values of the square root of the cross-structure function for east, north, and east-and-north velocity components computed between -100 and -500 m depth. The entries are for east, north, and combined in that order reading downward in each column. The units are centimeters/second. The depth offset at minimum in meters is shown in parentheses, where a positive value means column profile must be shifted down to agree with row profile.

	AP15U	XP215E
AP15D	1.2(0)	1.1(13)
	1.2(0)	1.4(15)
	1.2(0)	1.3(13)
AP15U		1.1(13)
		2.0(15)
		1.6(13)

Table 5. Minimum values of the square root of the cross-structure function for east and north velocity components computed between -100 and -480 m depth. The entries are for east and north in that order reading downward in each column. The units are centimeters/second. The depth offset at minimum in meters is shown in parentheses, where a positive value means column profile must be shifted down to agree with row profile.

	AP8U	AP9D	AP9U
AP8D	0.9(2) 1.2(2)	0.7(2) 0.6(2)	1.5(2) 1.4(4)
AP8U		1.3(0) 1.0(-2)	0.8(2) 0.6(2)
AP9D			2.0(2) 1.3(4)
	AP10U	AP11D	AP11U
AP10D	0.6(2) 1.0(2)	0.6(0) 0.5(0)	1.1(2) 1.1(2)
AP10U		0.7(-2) 1.0(-2)	1.0(0) 1.2(2)
AP11D			1.3(2) 1.2(2)
	AP12U	AP13D	AP13U
AP12U	0.8(2) 0.9(2)	1.2(-2) 1.0(-2)	1.2(2) 1.2(0)
AP12U		1.0(-4) 1.0(-4)	1.3(0) 1.4(0)
AP13D			1.1(4) 1.3(4)

VI. REFERENCES

- Drever, R.G., and T.B. Sanford, 1980: An expendable temperature and velocity profiler (XTVP). Near Surface Ocean Experimental Technology Workshop Proceedings, 6-8 November 1979. Naval Ocean Research and Development Activity, Bay St. Louis, Mississippi.
- Sanford, T.B., R.G. Drever, and J.H. Dunlap, 1978: A velocity profiler based on the principles of geomagnetic induction. *Deep-Sea Res.* 25: 185-210.
- Wenstrand, D.C., 1979: Measurements of vertical profiles of oceanic current and Richardson number near St. Croix, U.S.V.I. *J. Hydronaut.* 13: 69-76.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1 REPORT NUMBER	2 GOVT ACCESSION NO	3 RECIPIENT'S CATALOG NUMBER
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4 TITLE (and Subtitle) A COMPARISON OF VELOCITY PROFILES OBTAINED FROM AN EXPENDABLE TEMPERATURE AND VELOCITY PROFILER (XTVP) AND AN ACOUSTICALLY TRACKED PROFILER AT THE ATLANTIC UNDERWATER TEST AND EVALUATION CENTER (AUTEC)		5 TYPE OF REPORT & PERIOD COVERED Final Report
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20 ABSTRACT (Continue on reverse side if necessary and identify by block number) A series of nearly simultaneous drops of two velocity profilers was made at the Atlantic Underwater Test and Evaluation Center (AUTEC). One profiling method was based on the measurement of motionally induced electric currents by an expendable device. This profiler, the Expendable Temperature and Velocity Profiler (XTVP), was compared with an acoustically tracked free-fall device operated by personnel of the Johns Hopkins University's Applied Physics Laboratory. Based on drops separated by less than 100 m horizontally and about 50 minutes in time, the two sets of profiles were found to agree within about 1 cm/s rms for east and north horizontal velocity components.		

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